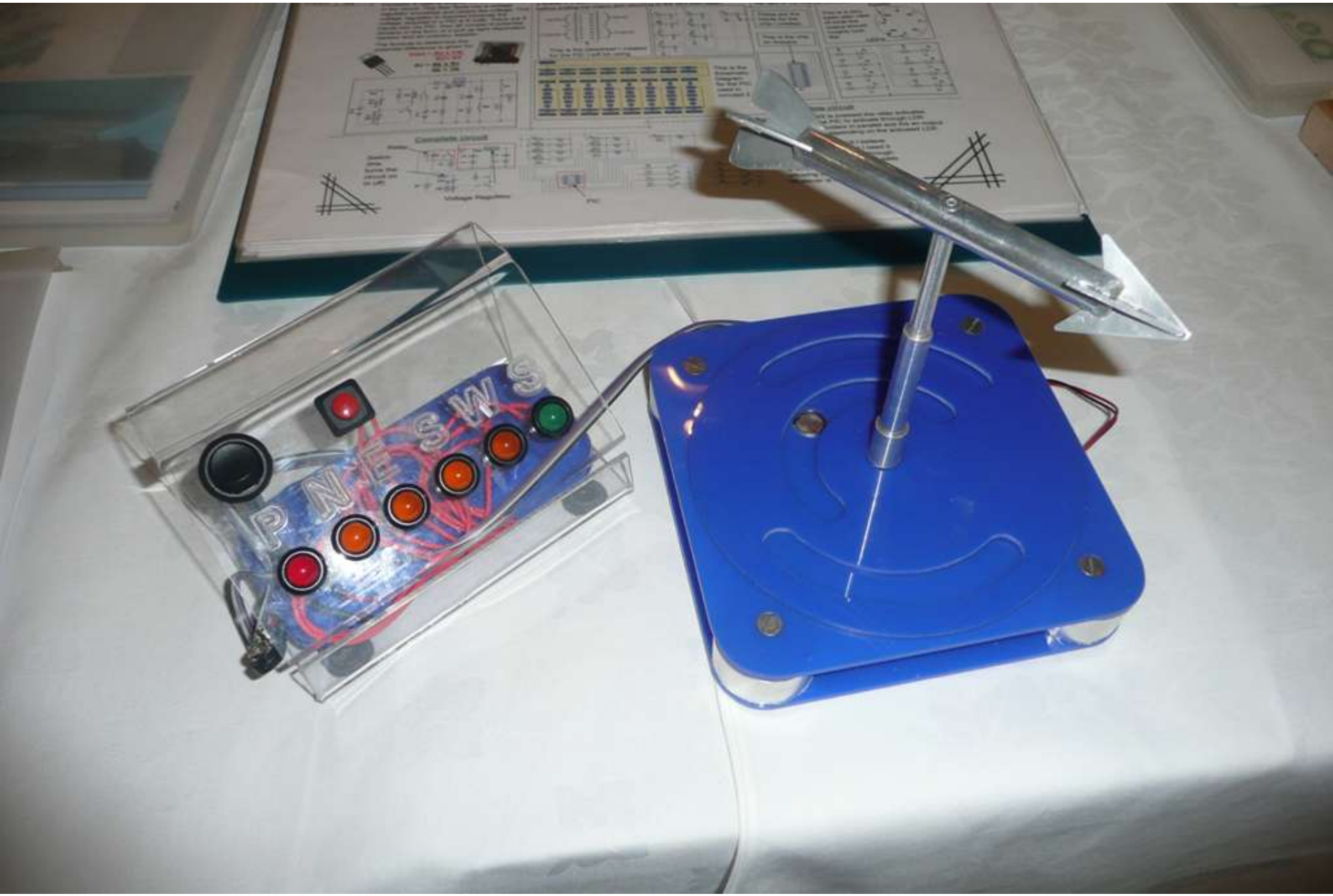
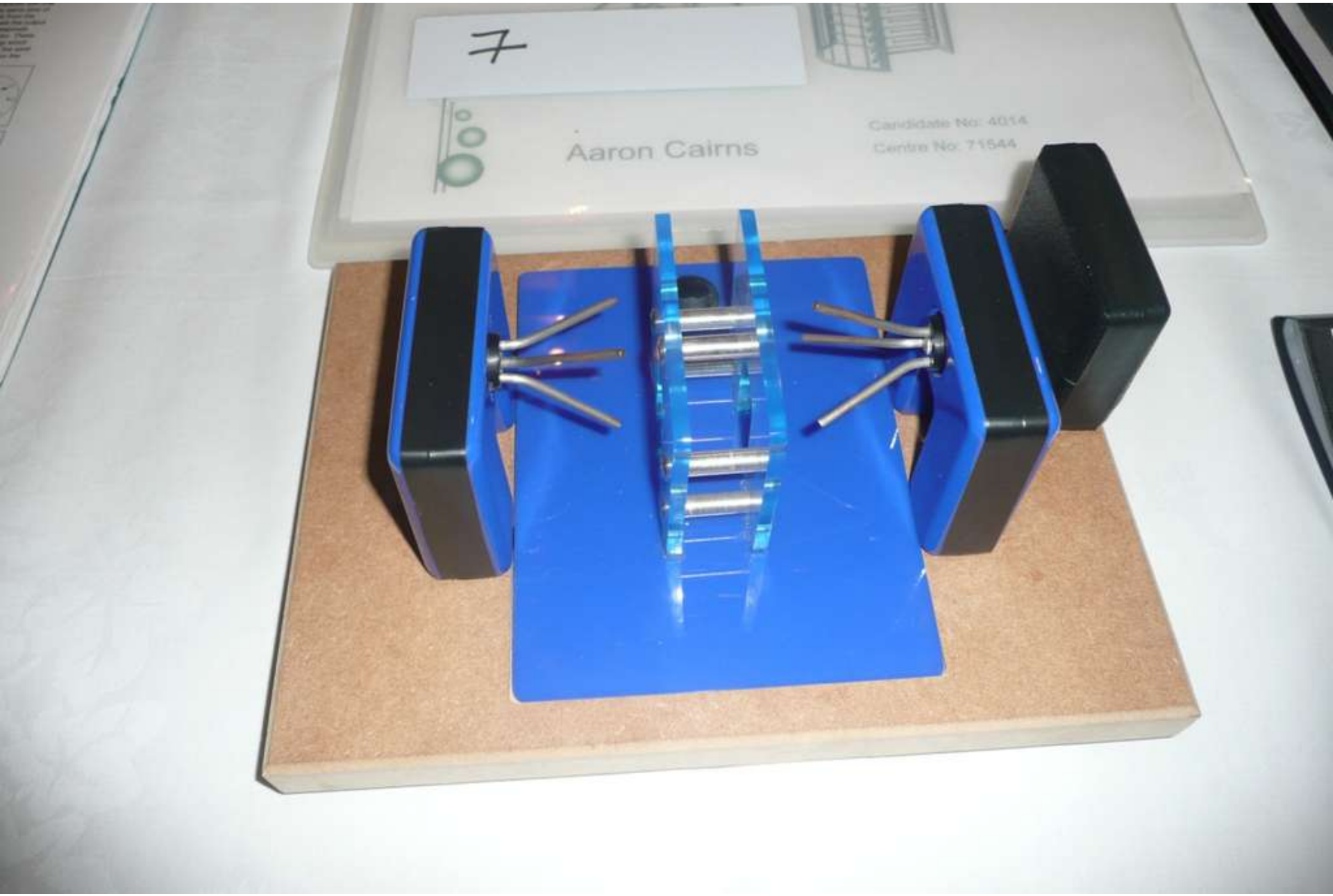
A2 Marks for Agreement trial 2011

	Project 1 POST DRIVER	Project 2 AUTO PCB	Project 3 MITRE POST CUTTER	Project 4 BAT TAPPER	Project 5 DRILL SHARP	Project 6 WIND VANE	Project 7 TURNS TILE	Project 8 SCORER	Project 9 CAR ALARM	Project 10 POWER SAVER	Project 11 LOGIC TOY
Identification of problem and, need and design Specification 6	4	4	4	4	5	4	4	3	4	3	4
Initial ideas, selection of ideas for development 20	16	16	14	10	18	18	16	17	20	17	10
Development 20	16	16	20	12	17	18	16	13	18	14	8
Manufacture 40	38	35	38	36	40	38	38	26	32	36	20
Testing and Evaluation 14	14	11	8	10	12	12	10	9	12	10	4
	84/90	80/86	82/88	70/76	90/96	88/94	82/88	66/72	84/90	80/86	48/54


N E S W


7
Aaron Cairns
Candidate No: 4014
Centre No: 71544


Cand
ntre Number: 71544


Unit A2 2:
Product–System,


Mark Ca
Candidate Number - 4025
ARM


1
2
3

A2 Technology Coursework

Turnstiles

Aaron Cairns

Candidate No: 4014

Centre No: 71544

Problem Identification, need and Design Specification

In the modern world today fire is a very real and possible risk to anyone working in a office building or a tower block. Being able to have a self dependent counting system for going into and out of the building would be a huge advantage. This would create a efficient administration system.

Problem: There is a large problem in fire safety drills, where someone has to do a role every time the pupils or office workers exit the building in a fire. This takes up time and the person taking the role has a strong chance that they will miss someone out or not hear the person, this is therefore resolved in a simple up/down counter system.

Need: From considering this problem there is a need for a product to keep track of people entering and leaving a building in a automated system without manual attention. Simple and easy to use counting system will help improve the safety especially during a fire etc.

Opportunity: There is a large opportunity for a product in the market like this, as there are very few of these sorts of products about and the demand for them would be high.

Design Brief: Design and manufacture a product that will count the number people entering and exiting a building in the event of a fire alarm is raised, the product will count the people exiting the building and if not all the people have exit the building the counter will show this on a display.

Table Showing Fatalities caused by Fire

	2003	2004	2005	2006	2007	2008
1-10	42	31	25	24	13	14
11-24	44	38	39	33	33	30
25-59	291	226	233	207	200	194
60-79	117	118	121	127	129	129
80+	82	83	58	79	69	70

Safety is a major part in modern living today. Here are some statistics of fatal casualties caused by fire. The main group of people concerned are the 25-59 year olds. Most of these people are more than likely office workers which have to travel up or down a lift to get to their office. In the case of a fire getting up/down stairs, your named sign off and evacuating the building could take time and further the risk of injury.

Design Specification

Background Info: Turnstiles these days are a useful way to count people walking in and out of a event or building. However in an office building an automatic check in system for counting the amount of people going in and out of the building would be greatly efficient and effective, also in the event of a fire this system would be a great way of knowing how many people are in the building. Turnstiles operate in different ways, some may use a micro switch to create a pulse whereas others may be turned on by LDR's. This is how I will make my circuit, using LDR's to change the light intensity and altering the voltage.

Materials: The turnstiles moulds will be made from a variety of materials. The housing to the electronics will be made from acrylic plastic, acrylic is strong and resistant to weather, corrosion resistant and can be easily cleaned. The turnstiles will be made from aluminium as it is light in weight, strong and durable. The display housing will be made from wood as it is cheap, can be easily worked with. Also when these materials are used together they are aesthetically pleasing.

Maintenance: The maintenance of the product wouldn't be high. The circuit should only need checking if it stops working and the turnstiles would only need the odd greasing or lubrication. This system is low maintenance and wouldn't require a lot of skills to keep it working.

Function: The products function is to count up or down when a person walks through a turnstile. It counts the number of people entering and then exiting the building. It will be operated using LDR's trigger the circuit and generate a pulse that will go into the microchips.

Ergonomics: The product will be operated by two turnstiles. One of them that counts up the other counts down. When the turnstile is turned a micro switch is pressed and activates the circuit in either the up/down movement. There will be three protruding legs coming out of the turnstile, they will be angled in the correct way so that when turned the top leg is at a horizontal position.

Performance: In order for the product to function to its full potential the person has to walk past the LDR which will sense the light change and change the value on the 7-segment displays. The turnstiles will only be able to turn in one direction, you will not be able to go back on yourself.

Aesthetics: Product will be made of aluminium, wood an acrylic. It will be designed so that the turnstiles move with ease and little effort, they will look sleek, no sharp edges and aesthetically pleasing to the eye.

Safety: The turnstiles will be curved with no sharp edg[illegible] pushed through, they will have no lower bars to injure yo[illegible] and the electronics will be packed away well out of the reach of people to prevent electric shock.

Product Target cost: As I will be building this on a 1:5 scale the cost of the full scale model will be around 5-600 pounds. However the smaller scale model will be about £99. When manufacturing a product like this it is important to keep the final cost of the product as low as possible to encourage consumers to buy the product yet at the same time provide a quality product.

Environment: The product will be used In a highly populated area as in office buildings or a sports ground. Therefore it will be used very often and has to be reliable and durable to its task.

Existing Solutions

Aesthetics

Aesthetically this product is bland and boring to look at. Its design is boxy, this product was designed for its function and not its aesthetic qualities.

Ergonomics

This product has been designed in such a way that it fits into the palm of the hand, this allows for easy operation of the clicker button. The turn- able knob on the side of the product has a serrated finish to it to make it easier to turn. Good anthropometry has influenced the design of this product.

Function

The function of the product is to count up. It is unable to count down. How ever the simple design allows it to count up easily and effectively.

Materials

The clicker is made from aluminium, this makes it light, easily machined and durable. The rotating reset turnkey is made from Acrylic plastic.

Aesthetics

The aesthetics of this product are more pleasing than product 1. The colour with the industrial yellow and black add character to it. The way the buttons are position on the clicker allows for simple use.

Ergonomics

Large and high contrast display makes it easy to read. The reset button is small and is slightly indented to avoid accidental reset. The Count button is large and produces a click that is felt and heard for reliable operation. The battery compartment is located on the side for quick and easy access.

Function

This product function is similar to product 1. It counts in only one way yet the display is digital. Also the reset is done by the touch of a button. This product would be able to give a higher number count as it has more LCD displays.

Materials

Made of high-impact plastic for durability and lightweight. This is a good example of materials used in industrial work.

Aesthetics

This product is very easy on the eyes and aesthetically pleasing. The simple design shows a clear yet efficient way of counting people. The brushed aluminium finish looks of a high standard and it fits into its environment well.

Ergonomics

This products design is simple an very efficient. The rotating arms are angled in such a way that they can easily rotate without to much effort. Also they have a fail away safety feature incase of a fire or emergency. The digital LCD display shows how many people have passed through in a hour or day.

Function

The function of this product is to count people passing a certain point. This is achieved well and affectively with its simple design.

Materials

The main body and rotating [illegible] are made from [illegible] professional

Aesthetics

This product is very aesthetically displeasing, it is very plain and boring, lacks character. The simple box shape doesn't help this and the colour scheme portrays a bland image.

Ergonomics

This product operates well and carries out its purpose effectively as you have very little buttons to press and with the swipe of a card you are clocked in. The product has wall mounts so it can be mounted to a wall to make it easier to operate from eye level.

Function

The function of this product is to clock people in and out of work or a office building. It does this simply and effectively.

Materials

The main material used in the product is polyethylene. It has good moulding qualities and is durable to everyday use.

Aesthetics

The aesthetics of the last product are good with a simple L shape design. However the colour scheme is yet again bland and lacking flare. The product has a blue backlit light adding a cool and professional display.

Ergonomics

The ergonomics are very good and simple. The to coloured buttons for counting up and down are clear and show a effective way of counting. It also has a reset button on the bottom of the counter. The shape of the counter allows it to be easily handled and used, with all the buttons within a fingers length.

Function

The tally counter above is used to count people, cars etc. this product can count both up and down with the simple touch of a button.

Materials

The main body of the product has been formed using polycarbonate plastic. Its properties are durable, easily machined and excellent for a mobile device like this.

Circuit Ide

Input

The circuit has two micro switch inputs. One input for counting up and the other for counting down. As the person walks through they trigger the micro switch. This sends a pulse from the monostable circuit to the u/d input in the 4510b chip. The switches and resistors act as a potential divider circuit. The equation for a potential divider is shown below.

$$V_{OUT} = V_{IN} \times \frac{R_2}{R_1 + R_2}$$

NUMERICAL ANALYSIS

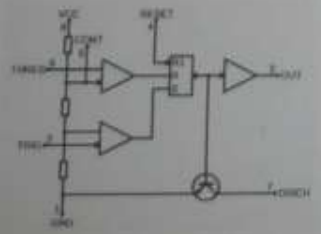
Potential divider measures voltage out. The amount of voltage being produced and entering into the process.

The input is controlled by a 555 monostable timer. As the switch is pressed it will send a pulse through the 555. This pulse will stay on for a set amount of time at the output pin 3. pins 4 and 8 go to the positive rail, while pin 1 goes to the negative rail. The timing for this can be worked out using a simple equation:

NUMERICAL ANALYSIS

$T_{sec} = 1.1 \times R \times C$

This is what the 555 timer looks like.



Process

The process of the circuit is controlled by the 4510b chip and the 4511B chip. The output pins from the 4510B chip connect into the 1,2,4 and 8 input pins on the 4511B.

The **4510b chip** is an integrated circuit. when a pulse is detected a the chip latches and produce an output signal of 1.

The 4511b receives the information or pulses from the 4510b and decodes the signals so that the 7 segment displays the correct number according to the pulse received.

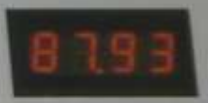
As you can see from the circuit diagram there is a PTM switch which is the reset switch for both the 4510b chips.

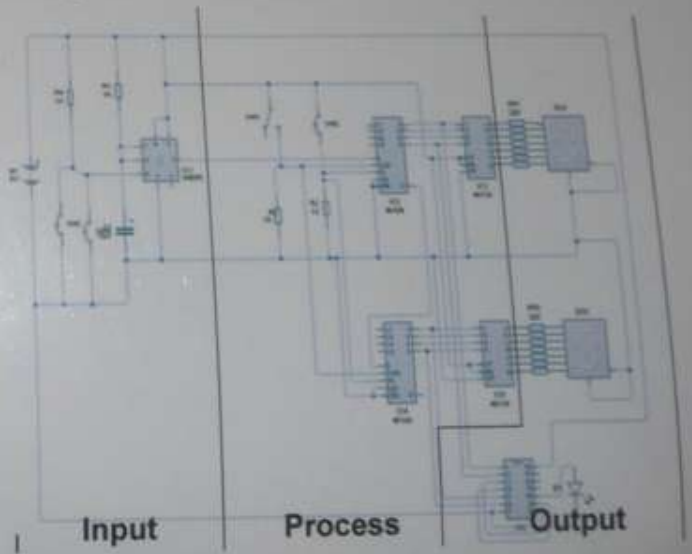
Also there is a SPDT switch, this controls the up/ down element of the product.

Output

The output of the circuit is a LED display showing the number of people entering and exiting the building or event. The LED display will receive a pulse from the 4510B and decoder, this decoder makes sure the LED display shows up the correct number according to the binary count.

An LED display are made up of light emitting diodes. They are used in many products such as store signs and billboards.





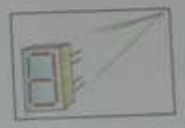
Initial Ideas 1

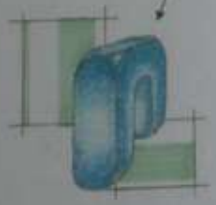
Below I have designed a number of different gateways for the counter circuit. They provide more style and character to the product. I have designed them in a way that the anthropometrics match the average waist height, therefore as the person walks past the LDR detects this and the resistance decreases. The designs look more aesthetically pleasing yet at the same time the ergonomics of the product work well and efficiently.

Lever micro switches will be situated here, as the person walks past they will brush past the micro switch and trigger the circuit.

Ergonomics- I believe that the micro switches greatly add to the workings of the product. They are easily activated yet effective at what they do.

Aesthetics- The designs below increase this products looks and add character to the product.





This design to the left looks similar to the main design, however it is taller and thinner. I included this for people who are taller than the average anthropometric height suggested.

LED's (light-emitting-diodes) are polarised components and must be connected round the right way. Common cathode LED display will be connected to the negative rail, common anode is connected to the positive rail. LED's come in different colours such as, Red, yellow and green. Seven segment displays need a decoder to produce the correct numbers 0-9.

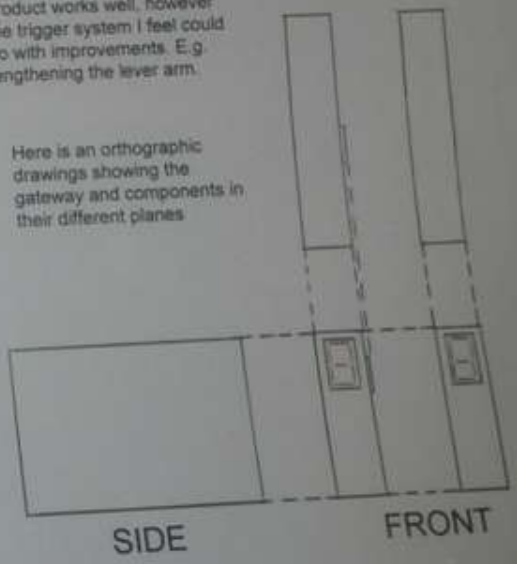
design is slightly bland and boring. The LED displays and LDR's would sit flush instead of slightly protruding from the finished product. I would make the edges curved as I've showed in my design for safety of younger users such as children.

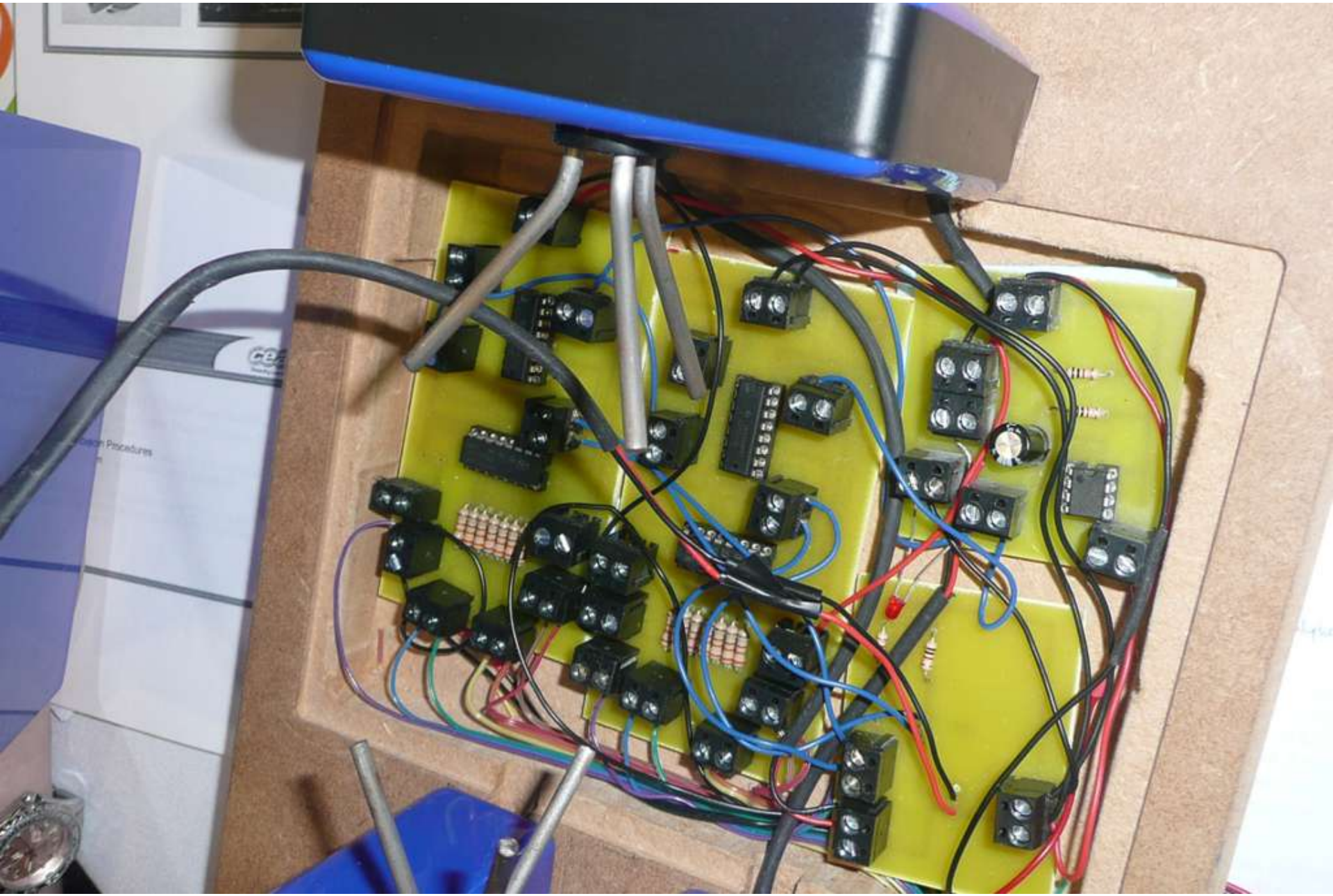
Overall I would rate this product around **6/10.**

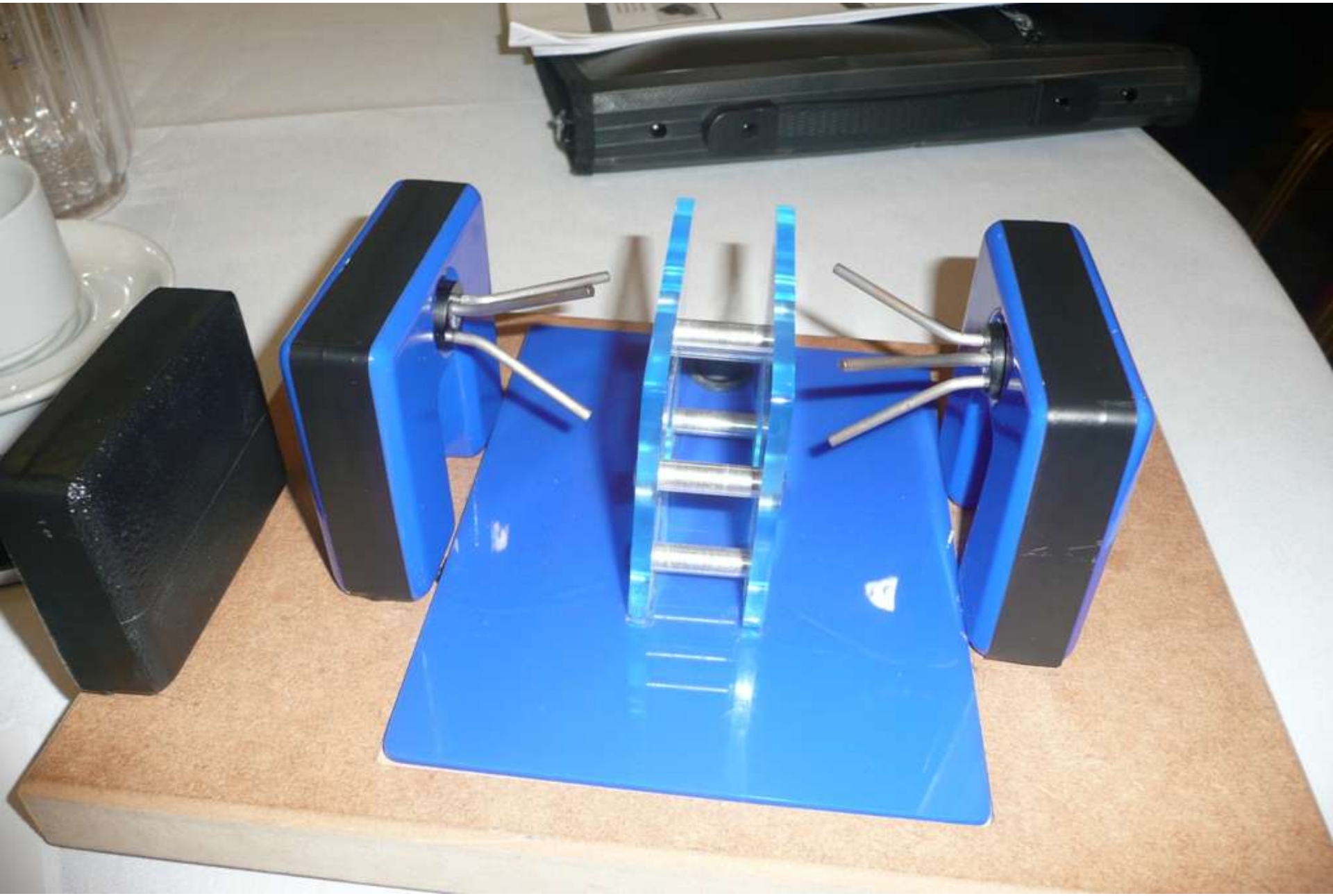
The main body or frame of the product will be made from aluminium or stainless steel. Both metals provide durability, strength and can be easily formed into shapes. Also the metals can be finished in such a way that it provides a stylish sleek look. The housing for the LDR will be made from Urea Formaldehyde as this plastic has physical properties of high hardness and toughness, which makes it suitable for knock-resistant electrical fittings, it is also a good insulator, a prime safety factor required.

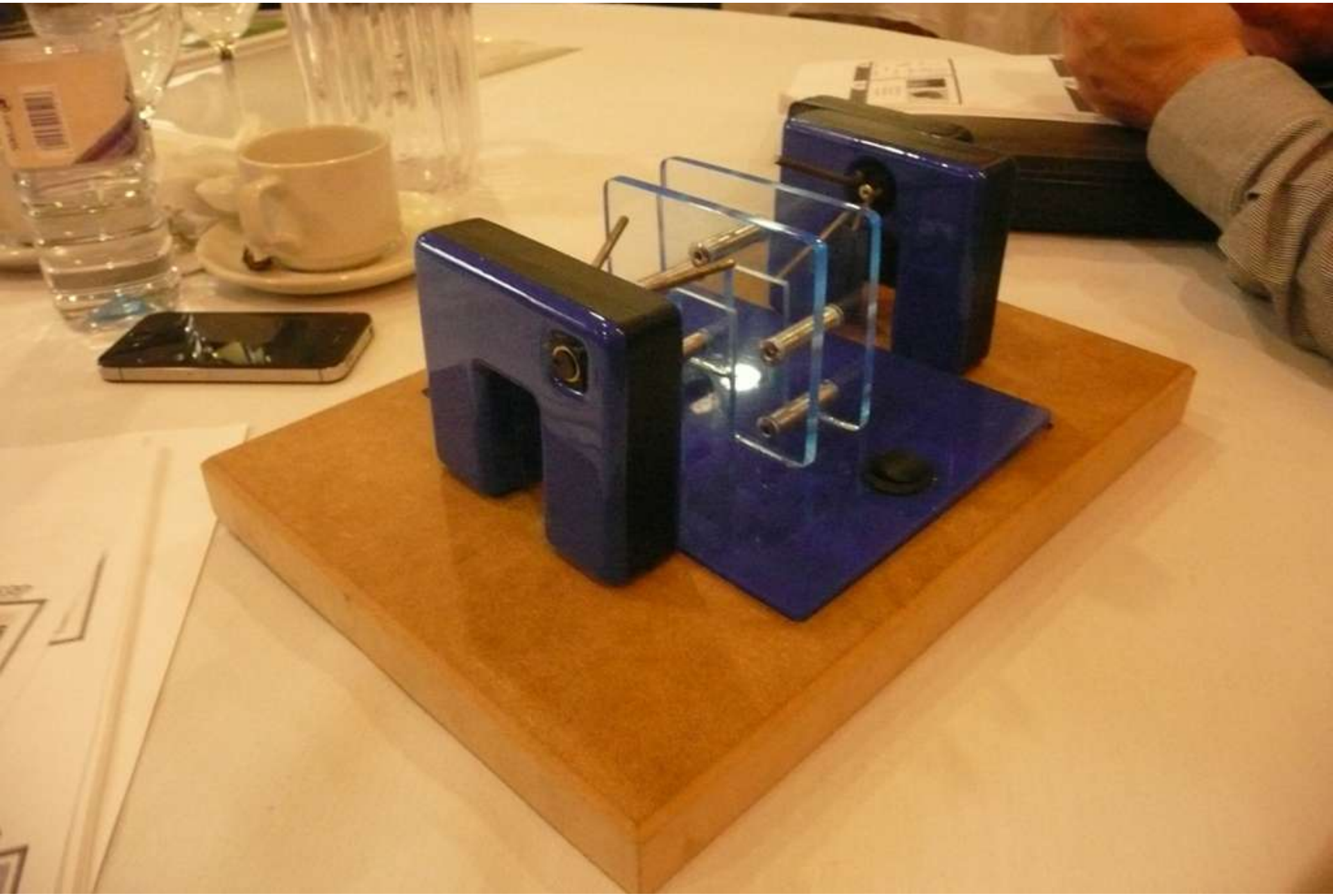
Function- The function of the product works well, however the trigger system I feel could do with improvements. E.g. lengthening the lever arm.

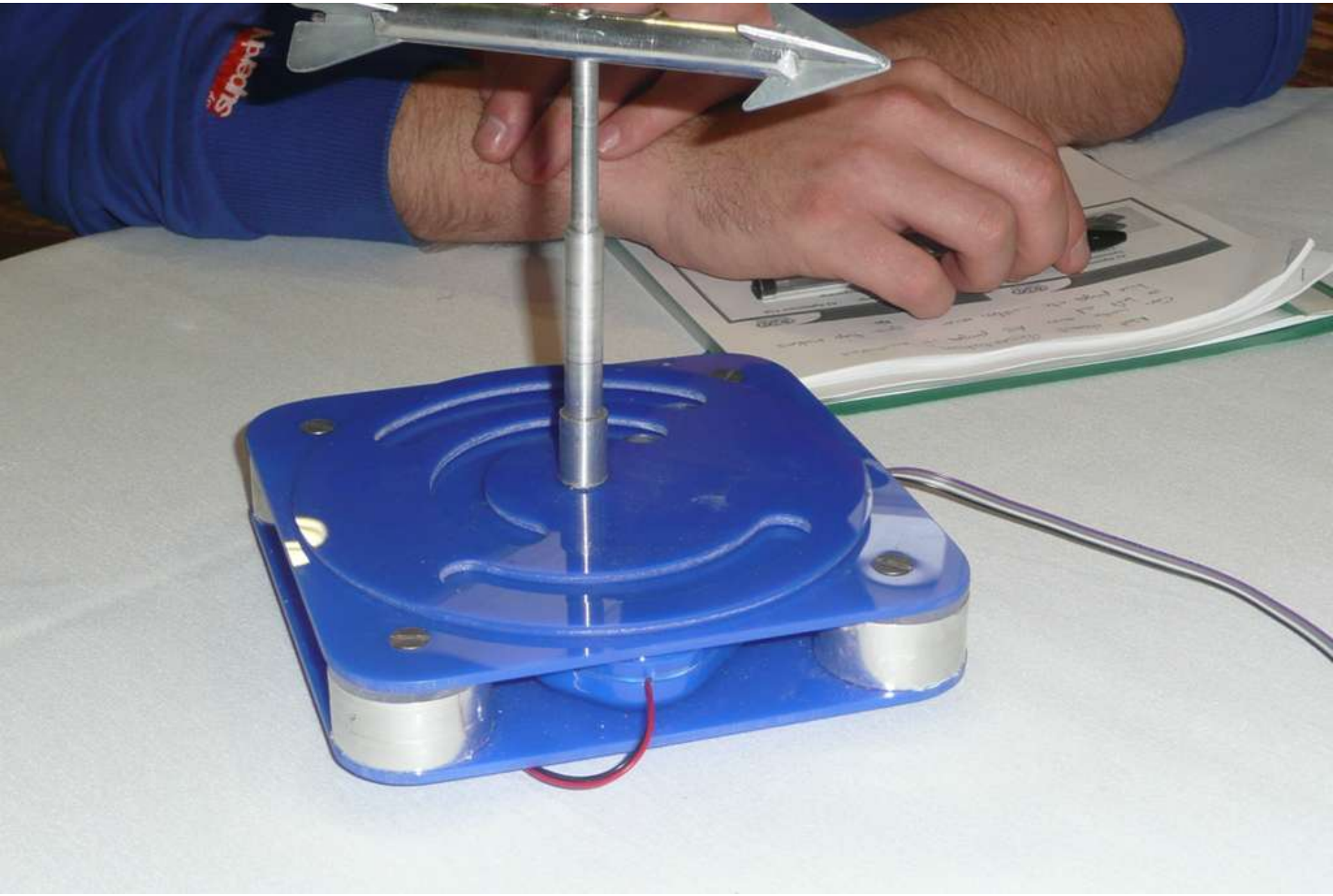
Here is an orthographic drawings showing the gateway and components in their different planes

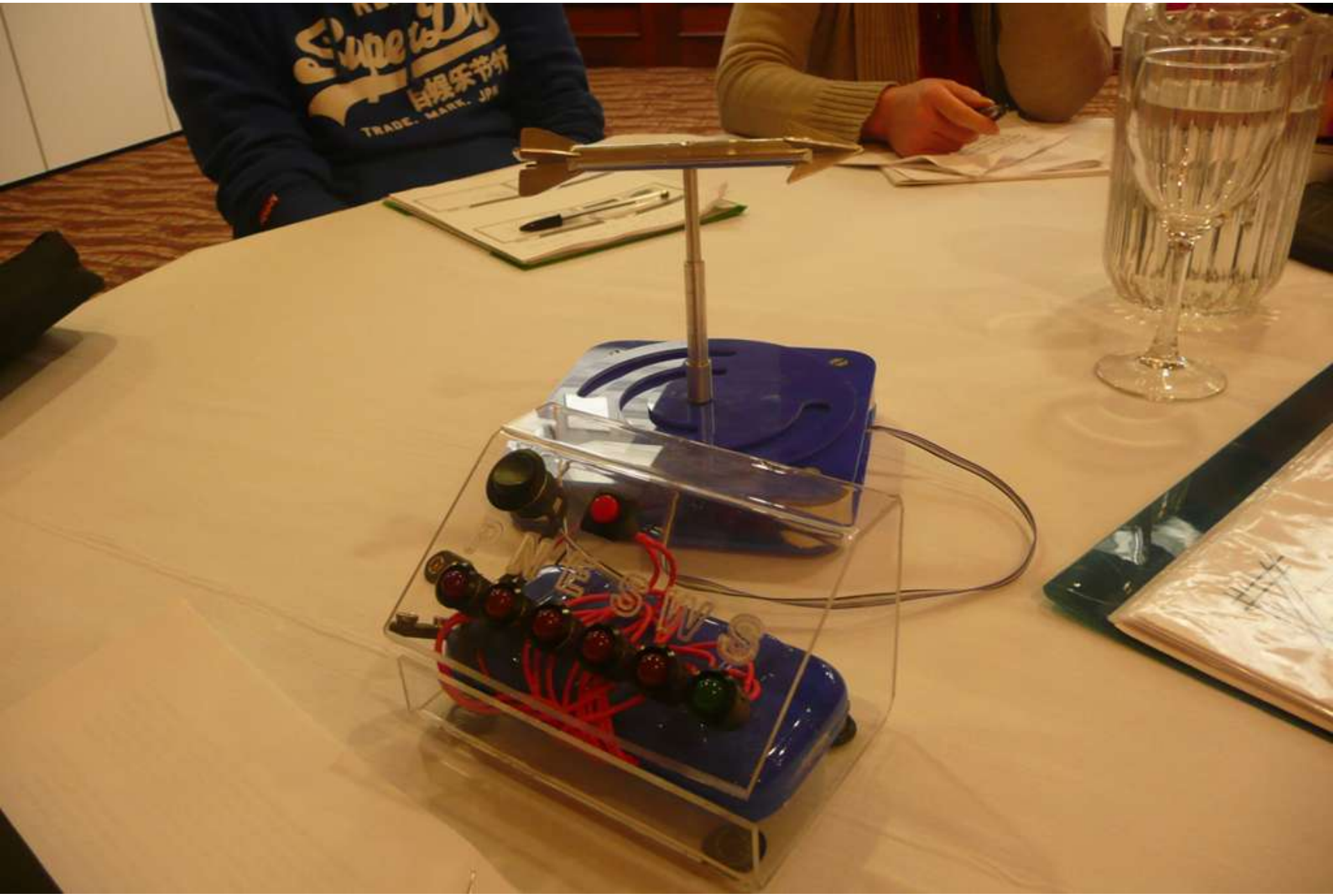













6
TECHNOLOGY A2 PROJECT -
WIND INDICATOR
Centre Number: 71544
Candidate Number: 4034

Problem Investigation

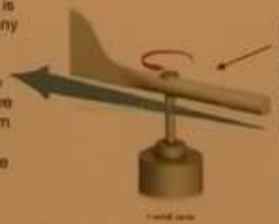
Background Knowledge

Sailing has provided a measure for transport and movement for thousands of year, it has been instrumental in the development of civilisations. Sailing is only made possible by the use of wind as the driving force on a sail so making the most of the wind available is a vital part of the art of sailing. To do this sailors have developed many means of showing the wind direction but none have been quite as successful as the humble wind vane. Wind direction is indicated by the direction it originates and its cardinal point which is North, South, East and West.

Various forms of wind vanes that have commercial and personal uses.

Problem Identification

Wind vanes are quite a common occurrence and their main purpose is to give the direction in which the wind is coming from are used in many different walks of life, they are used in the aviation industry, farming practices, large ocean going liners to smaller yachts. One of the problems with wind vanes is their need to be clear of other objects to give the most reliable direction of the wind which is usually high above its surroundings. This leads to difficulty with reading the direction from down on the ground or in the cockpit of a yacht due to the angle and the distance from the person to the vane itself. The vane can often be out of view which means its impossible to view the vane.



A diagram showing how a wind vane works. The blue arrow shows the direction the winds going and the red arrow shows the rotation of the vane. The vane always points into the direction of least resistance which is directly into the prevailing wind.

Ornamental vanes are used for decorative purposes and usually have animals on top of them.

This diagram shows how the cardinal directions.

Proposed Solution

What I propose to do is create an electronic device which allows the user to have an accurate representation of where the wind is coming from. I also want the device to have some method of displaying the wind direction and be out of sight of the user.

The input for the product would come from an analogue signal. This analogue signal would then need changed into a digital signal and expressed as a visual or audible output. To allow the output to be displayed while the input is hidden would require 2 separate units.

Detailed Spec

General Product Spec

Materials:

The product should include a range of materials that are able to withstand the elements as this product will be placed outside, and light, because if the product is too heavy it will not spin properly into the wind, causing inaccuracies.

They should be relatively cheap, costing no more than £20-£35 to purchase.

Ergonomics:

The buttons should be comfortable and within easy reach.

The visual display should be large enough so that it is easily read.

The product should be stable and level, and should include a feature that prevents it slipping on an inclined surface up to 25°.

Aesthetics:

The product should have a high quality finish which is striking and eye-catching.

It should have a high quality finish and a pleasing texture.

Size and Shape:

Product casing and wind vane:

The product casing and display should be no bigger than 45cm long, 20cm in width and 30cm in height so it doesn't take up too much space and no smaller than 10cm long, 8cm width and 8cm in height.

It should be made of at least two different types of materials and no more than 3.

The wind vane should be no bigger than 30cm in height with a base with width and length no bigger than 20cm. It should be no smaller than 7cm in height with the base no smaller than 6cm.

Safety:

The product should have no sharp edges that may injure or harm the user.

There should be no bare electronics that could mildly electrocute the user.

The base of the wind vane should be wide enough that the wind vane itself will not damage objects when it spins about its axis.

Circuit Spec

Input: There should be an input that registers the turning of the wind vane through 360° of motion.

Output: The circuit should be able to give either a visual light or an audible sound to show where the direction of the wind is coming from based on the inputs given.

The circuit should run be able to run on a 9V battery.

The PCB should be no bigger than 10cm by 6cm in area so it will fit neatly into the casing.

It should cost no more than £15 for all the components in the circuit.

The circuit should have some form of reset.

There should also be the ability to turn the circuit on and off when its not in use that doesn't require removing the power supply itself.

Existing Solutions

200 Series Wind Direction Vane

Ergonomics: This product works well as a wind vane as [illegible] aerodynamics.

Aesthetics: This product possesses good aesthetic qu[illegible] incorporated into a simple design through the contrast between the stainless [illegible] and the black body.

Function: This product works with a potentiometer as an input and a bar graph display as the output. It also has a ball bearing system to reduce friction.

Cost: £99.99

TA100 Wind Vane

Aesthetics: This solution looks good and has a bright white finish to it which really makes it stand out.

Function: This product reads the direction of the wind and also includes an anemometer to find the wind speed as well making this a well designed product. It has a good display that has various backlight settings making this a very high quality piece.

Ergonomics: The entire product is very light due to its carbon fibre construction with the use of high quality materials.

Cost: £179.99

Sunpro Wind Vane

Function: This wind vane has no electrical system. To determine the wind direction you have to look at the wind vane itself and determine the direction from the four prongs below the vane.

Aesthetics: The aesthetics of this solution are very simple, with cost in mind when it comes to the look given.

Ergonomics: This product doesn't work as well as similar products due to its very angular shape.

Cost: £47.99

Raymarine ST60

Function: This vane is very similar to the others on the market except it also has a thermistor-heater circuit incorporated in the design for cold weather that could disrupt the accuracy of the vane.

Ergonomics: This product has a pointed nose and large tail fin to give good accuracy so is therefore well designed.

Aesthetics: Like the first product this solution has aesthetic appeal and the polished aluminium nose is striking and stands out. However it has a large fin to help stabilise it in fast winds.

Cost: £109.95

Nexus Wireless Wind Transducer

Aesthetics: This product has very striking and in terms of its aesthetics. It has a bold design which makes it different to many other wind vanes out there.

Ergonomics: Due to its double fin construction this product is highly accurate and highly stable platform for finding the wind direction.

Function: this product unlike and other electronic vane has a wireless transmitter removing the need for long and complicated wiring.

Cost: £144.99

Concept & Circuit

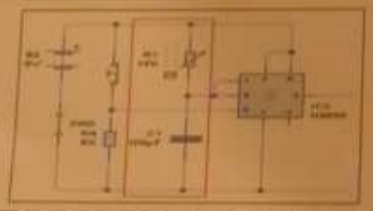
Input

Pin layout for 555 chip

I used a 555 monostable circuit as my input because it is possible to press a PTB switch for a short period of time and give a longer output pulse. This pulse can varied depending on the size of the resistor and capacitor connected to pins 6 and 7 in the arrangement shown below outline in red. The equation to work out the time period is also below in red writing. I also added a switch to turn off the circuit completely ensuring the battery is not wasted.

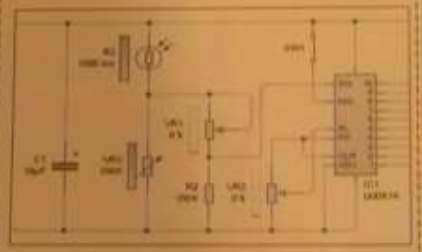
Time Period=1.1(R1 x C1)

1.5seconds=1.1(15000 x 0.0001)



Process

The process for this circuit is the LM3914 16 pin chip. The main input for this particular chip is a 555 monostable circuit but it also has other inputs which change the various processes which occur within the chip. R3 is an LDR which changes its resistance with a change in light levels with VR3 (variable resistor) helping to vary the sensitivity of the output from R3. To change the brightness of the output, VR2 (potentiometer) can be changed. The output of the LM3914 can be changed from a bar graph display to a dot graph by changing SW1 to switch from an on to an off position.

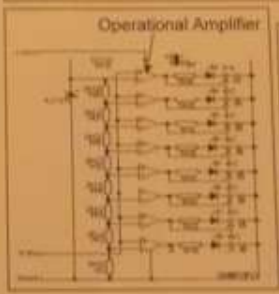


Output

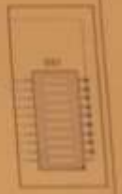
The output for my first concept is a bar graph display. The bar graph display is made up of three main components, resistors, LED's and operational amplifiers. LED's are connected to the negative pole of the operational amplifiers. These act as a reference voltage, any voltage below this reference and the operational amplifier will not activate and the corresponding LED will not light. As voltage enters the display it activates the op amps. As voltage increases more op amps will activate causing the LED's to give a visual demonstration of how much voltage is flowing in the circuit. As in any circuit involving LED's resistors must be placed before the LED to prevent them from being blown by too great a voltage level entering them.

This is the bar graph display with the LED's, Operational Amplifiers and resistors all incorporated in the same case. It prevents any of the components from being left out when the circuit is built.

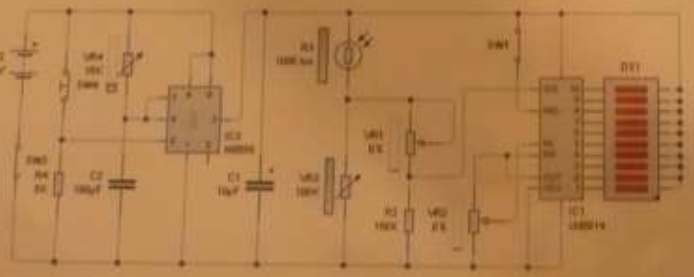
Operational Amplifier



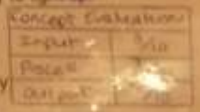
This is the op amp as shown in Livewire. The wires coming in from the left are coming from the LM3914 chip and the wires coming out of the display to the right are all connected to the positive rail to complete the circuit.



Complete circuit



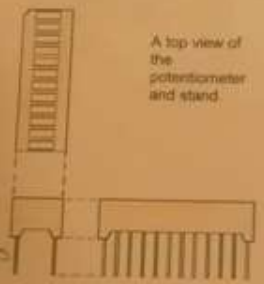
This is my complete circuit, it is designed that when the PTB switch is pressed it causes the 555 chip to allow an output to run for a given time. This activates a Light Dependant Resistor which in turn allows a percentage of the bar graph display to light up.



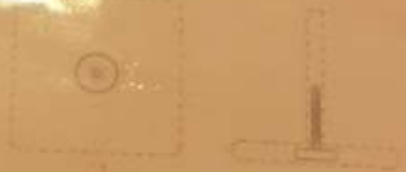
In conclusion I think this circuit has some potential in terms of uses in my final circuit. It is a relatively simple circuit and fits the purpose with which I require it to do.

Concept Sketches

A 2 point perspective drawing of a bar graph display



A top view of the potentiometer and stand



A side view of the wind vanes stand. This drawing shows the potentiometer and how it is used in relation to the bar graph display

A front view of the stand and potentiometer.

The arrow is to attached to the upright via some form of ball bearing system to reduce the coefficient of friction and allow the arrow to spin freely.

There is an aluminium metal upright which is attached to the base via the a high strength glue.

The main part of the arrow is also made of wooden dowel rods to be lightweight with an aluminium tip and fin of the same weight to make sure the arrow is balanced as possible.

There are wooden dowel rod supports to steady the upright in high winds.

All edges of the product are to be rounded off to prevent injury and to prevent things from catching on it.

The vane is to be made of an polished acrylic base

A small wooden lip should surround the display to protect it and prevent it from being scratched or hit by any objects that should come near it.

The bar graph display will be positioned horizontal along a 30° slope to allow it to be seen from various angles so it doesn't have to be viewed from just above or directly at it.

The container for the circuit will be made out of vacuum formed plastic due to its lightweight material and ease of construction.

The display for the circuit is to be included in one unit along with the on/off toggle switch, the reset PTB switch and the potentiometer that affects the brightness of the bar graph display.

The letters N, NE, E, SE, S, SW, W and NW will be engraved above each separate display indicating the direction the wind is coming from North clockwise round to NW.

All components should be within the one container that is at least splash resistant, if not completely watertight to prevent water damaging the circuit.

All the switches should be have a soft touch rubber case with various grooves to give grip for when the object is used in wet conditions.

As with the vane, the container should have no sharp corners.

Concept 2 Circuit

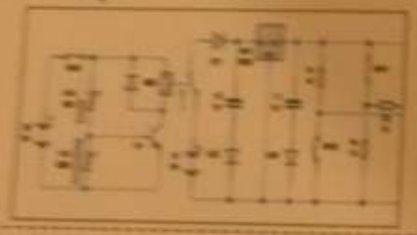
Input

The input for my circuit is a potential divider consisting of 2 resistors (1 a variable resistor) leading to a transistor that activates a relay. This relay has a diode set to create a loop if the relay breaks, this diode protects the transistor from the high voltage which occurs for a short length of time when the relay is switched off. The transistor is used to amplify the current flowing in the circuit. This then flows into a voltage regulator smoothes and lowers the voltage. This voltage regulator is required because the voltage required in a PIC is 5 volts. There are 8 inputs into my PIC, they all consist of potential dividers in the form of a pull up light dependant resistor and an ordinary resistor.

The formula to determine the potential difference is given by:

$$V_{out} = \frac{R2 \times V_{in}}{R2 + R1}$$

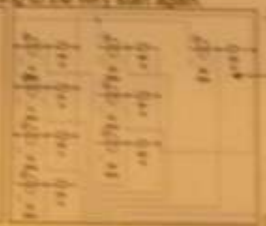
$$4v = \frac{4k \times 6v}{4k + 2k}$$



Process

The process in the second concept circuit involves the use a PIC. It would be nearly impossible to find a chip that could do exactly what I wanted so I had to programme one myself using PIC Logicator. Once the circuit starts it enters a digital switch. If LDR1 is covered it starts a macro, if it isn't covered it moves to the LDR2 and so on through to LDR8 in a clockwise motion. Each macro does the same thing except with a different output LED. The macro is initiated, turning an LED on for 0.5 of a second. Next it turns the LED off for a further 0.5 seconds. This process will repeat a further 4 times before ending the macro and returning to the very start again.

This is the datasheet I created for the PIC I will be using.



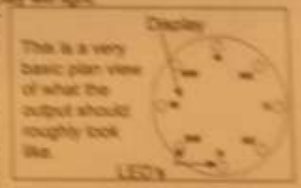
This is the Schematic Diagram for the PIC used in concept 2.

Output

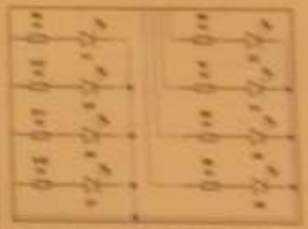
Concept 2's output is very simple compared with that of the first concept yet still displays the same kind of data. The output for this concept comes from the PIC I designed on PIC Logicator and uses the output pins 8-10 inclusive. Each output pin corresponds with an LED which is protected by a resistor. These LED's will each have a sign beside it stating which direction the vane is facing. For example, if the wind is coming from the North East then an LED on the top right of the display will light.

These are the inputs for the chip I created.

This is the chip on livewire.



This is a very basic plan view of what the output should roughly look like.



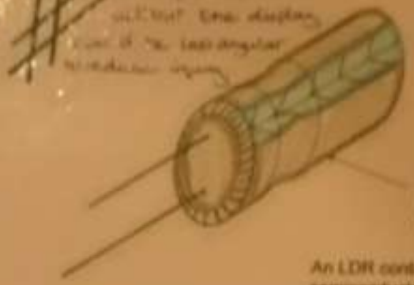
Complete circuit

When SW2 is pressed the relay activates causing the PIC to activate through LDR potential dividers in parallel and the an output LED lights depending on the activated LDR.

As a complete circuit I believe this does exactly what I need it to and could be carried through to the final circuit. The PIC adds a lot of flexibility to the circuit allowing the circuit to do whatever is required.

Complete circuit

Concept 2 Sketches

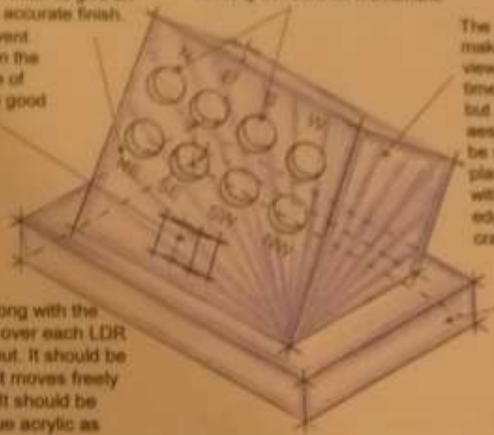


This is a capacitor and is essential in the working of a 7805 voltage regulator. This capacitor is unpolarised allowing it to be connected to the circuit with each leg being either negative or positive.

This is the vane for concept 2. It is to be made of lightweight aluminium due to its rigid and weather proof nature. It needs to be well balanced about a central point to give accuracy in its reading.

The letters on the display should be created using a router to give an accurate finish.

Each of these holes contains an LED which is activated depending on which direction the vane is pointing thus giving an accurate direction of the wind. The LED should fit snugly into the hole leaving no room for movement.



The display is at an angle to make the LED's easily viewed. I was unaware at the time of drawing the display but the angle also looks aesthetically pleasing. It is to be made of vacuum formed plastic as this is waterproof with aluminium covering the edges to prevent it being cracked.

The base for the display is wider than the rest of the display to give it a sturdy platform to keep it from falling over. It should be made of wood to also make sure the display is bottom heavy and wont fall over damaging the display.

An LDR contains a semiconductor. If light falls onto this the resistance decreases allowing it be variable due to the lighting.

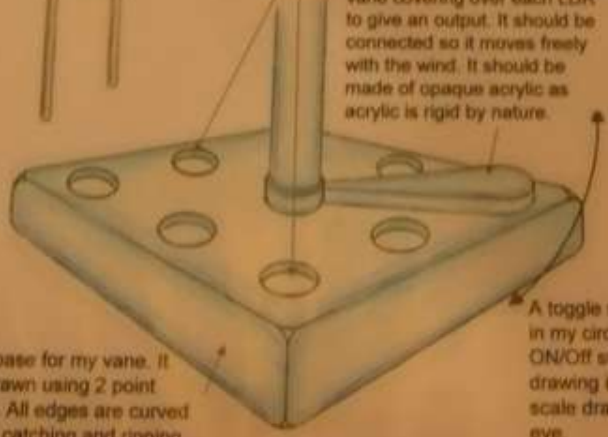
This is the On/Off button to prevent the battery being run down when the product isn't in use. To be made of polished aluminium as it gives a good finish.

The Voltage Regulator is essential in any circuit involving a PIC chip as it changes the input voltage to around 6v, the voltage a PIC chip works at.

I drew this Voltage Regulator orthographically.

This is an LDR, it is the part of the input for my circuit and there is 1 of them inserted in each of these holes in the base.

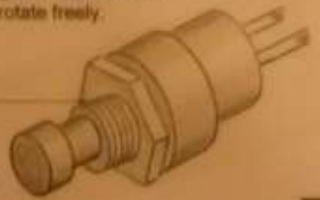
This rotates along with the vane covering over each LDR to give an output. It should be connected so it moves freely with the wind. It should be made of opaque acrylic as acrylic is rigid by nature.



The upright, the vane and the acrylic that covers the LDR's are all connected so that if 1 rotates they all rotate. The upright is slotted into a groove in the base, allowing it to rotate freely.

This is the base for my vane. It has been drawn using 2 point perspective. All edges are curved to prevent it catching and ripping sails as if they touch it.

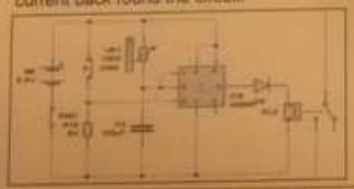
A toggle switch is used in my circuit as the ON/Off switch and the drawing is an accurate scale drawing drawn by eye.



Concept 3 Circuit

Input

For my third concept I used a monostable circuit as my input. This is a very similar circuit to the circuit I used in concept 1 with a few key differences. Instead of an LDR in the potential divider I used a variable resistor. This allows the output pulse of the monostable to be varied manually by the user. This output pulse activates a relay which in turn activates the rest of the circuit. The relay is a large mechanical device and when a current flows through it the relay acts like a magnet. There is an armature and when this is magnetised it touches a contact completing a circuit. A relay is used in my circuit because there is another circuit which needs to be activated by the monostable but not connected to it. A diode is always used in connection with a relay to prevent the flow of current back round the circuit.



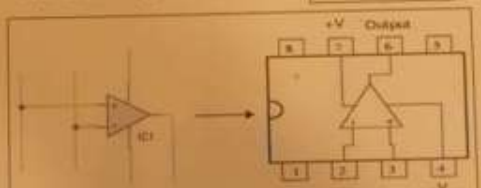
Another input in my circuit is the LDR and it is light resistant and acts only when there is an output pulse from the monostable circuit.

The diode has to placed in a particular way in the circuit to allow current to flow.

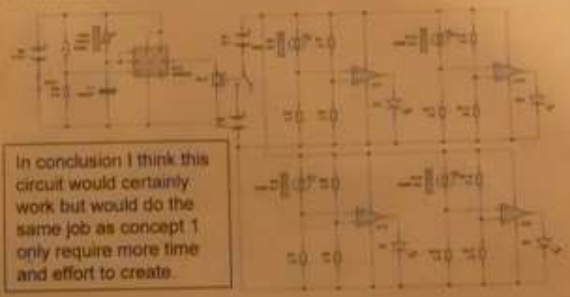
Process

There are 2 main processes in my circuit. The first is in the input as is a 555 chip working in its monostable state providing a pulse for a time period when the switch is pressed. The second process in my circuit is the operational amplifier. The operational amplifier only produces an output when the input voltage is above the reference voltage produced by the potential divider.

I used an operational amplifier as my main process because it allows the analogue output of the LDR to be converted into a digital output for the LED. The LED is therefore only in 2 states, on or off, ensuring there can be no mistaking where the vane is facing.



An op amp is actually contained within a chip and this is the pin configuration of that chip



In conclusion I think this circuit would certainly work but would do the same job as concept 1 only require more time and effort to create.

Output

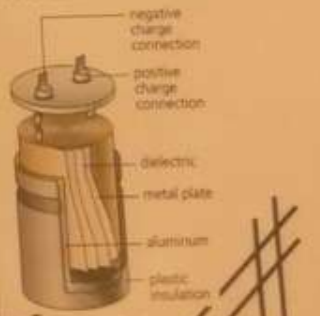
The output in this concept circuit is an LED, similar to the LED in concept circuit 2. These particular LEDs flash instead of being continuously on. There isn't many other ways I could create an output that displays the direction of the wind and where its coming from. One other method of displaying the direction would be with the use of a bulb. The reason I didn't use these is due to their high power usage, low durability and their low efficiency rating. They also are made of glass which if broken (which could very easily happen in this particular environment) could be very harmful to surrounding people.

Picture of a typical broken bulb.

This dot represents a flashing LED, if this dot was not here it would just continuously create light.

Complete circuit

This is what the inside of a capacitor looks like. It is built up of one long sheet of wire and a sheet of insulation that are both coiled tightly together.



Concept 3 Sket[illegible]s

The majority of the pictures on this page are free hand sketches to show the development of certain aspects of this concept.

Wide base made out vacuum formed plastic with the mould contained inside to give a stability.

This part contains the circuit.

Variable resistor.

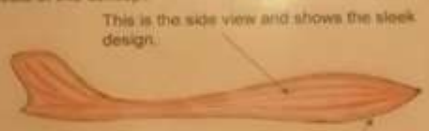
Reset switch to reset the circuit.

On off switch to conserve power.

LEDs, there is a similar set up on the opposite side so it can be viewed from both sides.

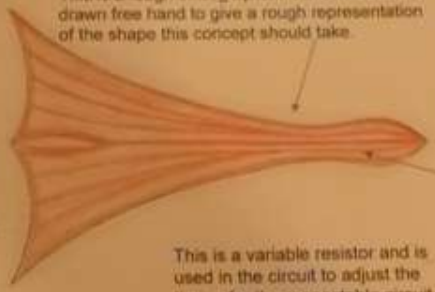
There is a protective casing over the main body to stop the LEDs being broken or the reset being accidently pressed. This can be removed and is held on with clips. It is made out of clear perspex.

This is the side view and shows the sleek design.



This is the front view of the arrow.

This is a rough orthographic sketch that was drawn free hand to give a rough representation of the shape this concept should take.



It is a very fluid design which would have good aerodynamics but also be stable and accurate which is what is required from a wind vane.

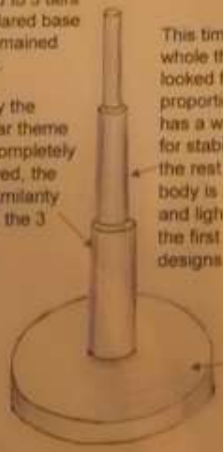
This is the plan view with the nose on the right and the fin and tail being to the left.

The first upright had 4 tiers and was very angular. It had a large base finishing with a slim upper tier.

This was then reduced to 3 tiers with a flared base but it remained angular.

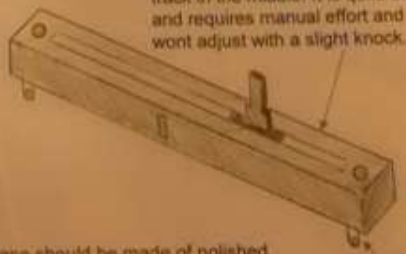
Finally the angular theme was completely removed, the only similarity now is the 3 tiers.

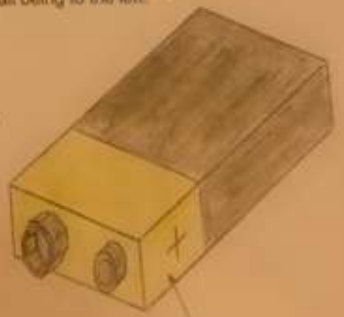
This time the whole thing looked far more proportional. It has a wide base for stability but the rest of the body is slimmer and lighter than the first two designs.



The bottom tier looked very out of proportion to the top but it was like this to give a sturdy base with a low centre of gravity.

This is a variable resistor and is used in the circuit to adjust the timing for the monostable circuit. This particular variable resistor is a slide resistor and moves along the track in the middle. It is quite stiff and requires manual effort and wont adjust with a slight knock.





The 9 volt battery is used extensively in every circuit and is usually a heavy duty and compact object.

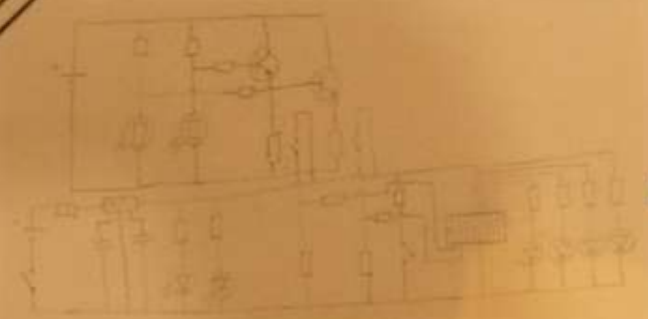
The base should be made of polished aluminium and the tier should be made of clear acrylic with an aluminium rod is the centre for strength.

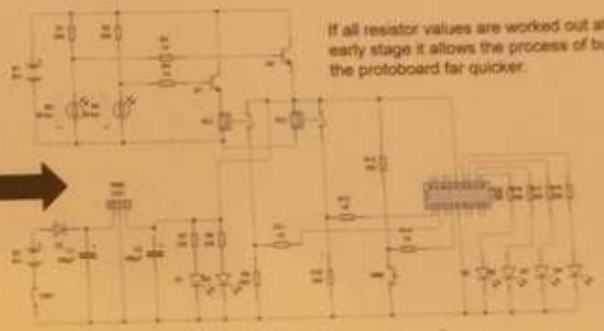
This is a pin that is usually soldered to wire to allow the resistor to work.

Aesthetics

I would probably change the nose and the upright so it was a mix of the second and third tiered design.

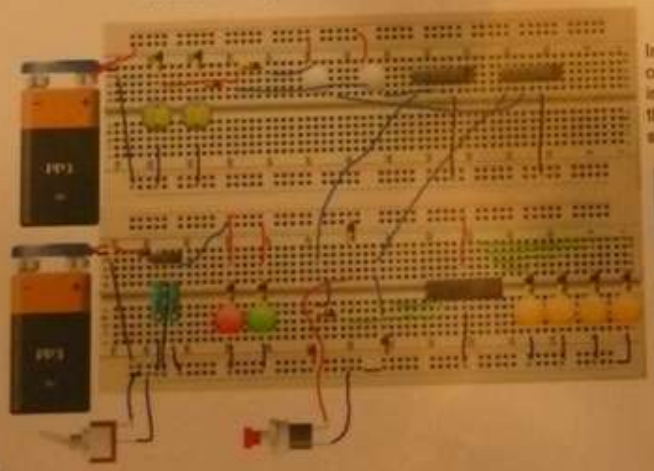
Final Circuit





If all resistor values are worked out at this early stage it allows the process of building the protoboard far quicker.

This is the initial drawing of the circuit. It is what I based the rest of my circuit on and the livewire is nearly an exact replica.



This is the circuit taken from livewire and made up on Circuit Wizard.

Initially when building the circuit on the breadboards the first input was created which would then be replicated again for the second input.

This is the livewire drawing and I referred back to it constantly when doing my protoboard.

This picture is of the circuit with the LDR covered over imitating dark conditions. This shows that the reed relay will be activated in low or no light conditions.

This first picture is of the circuit without the LDR covered over in light conditions. This shows that the reed relay will not be activated in normal light conditions.

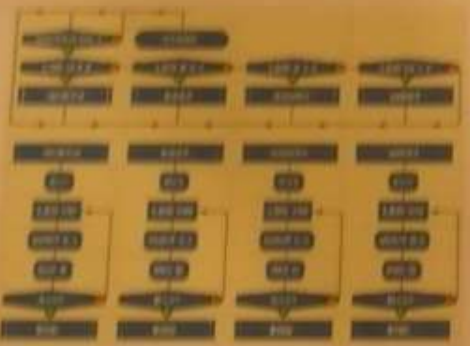
In both of these photos there is an LED this will not be in the final circuit but to prove that current isn't and is flowing in the respective pictures.

This picture is of the completed circuit with the PIC connected, The voltage regulator connected and all the outputs (LEDs) connected. Also included is 3 LEDs which will show port (left) and starboard (right) on the boat in their respective colours of green and red. They will be on whenever the circuit is on. Neither of the inputs are covered over. Therefore the circuit will give a wind direction coming from the North. An on/off switch is included to allow the circuit to be turned off when not in use.

Final Circuit Po... 2

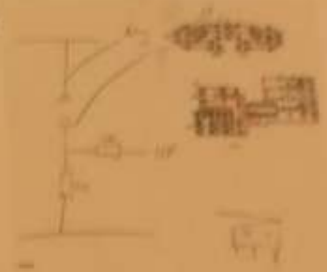
This is the second draft of PCB wizard which still had a lot of mistakes but was a vast improvement on the first. For example, there was still no grounding going to the PIC. This time the LEDs had been added but not added correctly

This is the PIC programme which I created on PIC Logicator. When the programme starts it goes through a series of digital decisions and based on the inputs selects a Macro for the programme to run. Once the macro finishes the programme goes back to the beginning again.



Previously in the year when learning about electronics we had designed and created a 7805 voltage regulator which I used in the protoboard instead of creating it from scratch

This is the first draft of the PCB which had a lot of mistakes which is to be expected first time round. The transistors needed changed in the inputs. There were resistors missing from all the inputs in the main circuit. 2 resistors missing from the reset, the terminal block for the on/off switch was missing, both LEDs had been left out and both the positive wire and ground wire were missing for the PIC. A few diagrams had been added to give clarity to some of the mistakes.



Somebody trying to explain that microswitches were better than LDRs but with no moving parts it was hard to see why LDRs were perfect for the project.

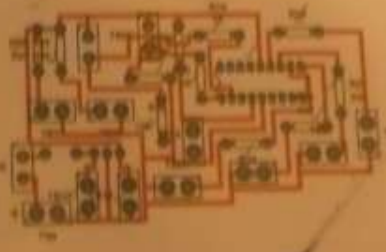
Neither outputs are covered over in the picture on the left giving a North reading

1 output is covered over which gives a corresponding wind direction coming from the East

I removed the bottom LEDs for the final circuit as they weren't necessary. Only 1 set of LEDs was required

Both outputs are covered over to show the wind is coming from the West

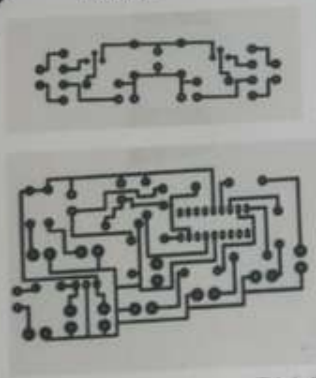
This time the other output is covered over and the first output is uncovered which gives a wind direction coming from the South



This time all the mistakes have been corrected. The circuit has been made as small and compact as possible without making the terminal blocks impossible to fit into the board. All the correct values for the resistors have been added. It is now ready to be printed out on acetate to be made into the PCB.

Final Circuit Page 3

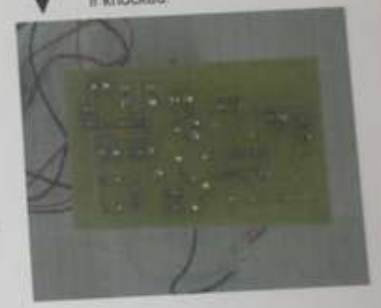
This is the circuit on acetate ready to print onto the PCB.



Some of the components used in the circuit set out ready to solder into the circuit. If this is done in advance it can save valuable time in finding components.

All the components that leave the casing need to have extra wire soldered on and then this wire needs shrink wrapped to prevent it from being damaged.

While soldering the circuit it is essential that you make sure you get solder on the component and the board in equal measure, if this is not done correctly the components may come out if knocked.



The final circuit soldered and completely working. This was a very happy moment and a big step in the making of the project.

This is the final circuit completed and being tested. The input circuit had not been attached yet.

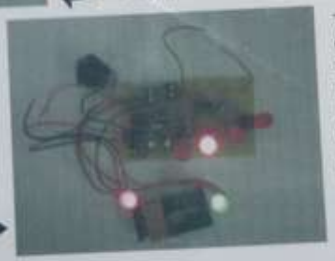
This is the circuit in its "off" stage.

This is the (0.0) input state otherwise known as North. This gives an output that goes to the led at pin 10.

Trying to find batteries that had a high enough voltage (close to 9v) so buying a battery was the only option.

This is the (0.1) input state known as East. This gives an output that goes to the led at pin 11.

This is the (1.0) input state known as South. This gives an output that goes to the led at pin 12.



This is the (1.1) input state known as West. This gives an output that goes to the led at pin 13.

Final Development

Plan View

This is fin of the arrow

Without these cuts into the disc the whole project would not work

The disc will be attached to the arrow and will rotate freely clockwise or anticlockwise with it.

This disc is to be made out of acrylic and will be cut out using a CNC machine.

The arrow head is created using wood which has been sanded down to a blunt point (to keep it safe). Once done this should easily point in the correct direction of the wind.

The upright is to be made out of aluminium which is polished to make it aesthetically pleasing.

The fin is aluminium and will be drawn out by hand and then cut, filed and then polished in keeping with the tip of the arrow.

Side View

This is an orthographic drawing of the vane with [illegible] and the safety of the product.

This is the 3-Dimensional drawing of the product and it looks very well proportioned.

Plan View

This originally was 1 drawing on solid works but if rotated it shows you all the other angles which is how I got the pictures on this page.

The base is to be made out of vacuum formed plastic to allow the mould to be held within it. It will also have a dip the radius of the acrylic centrepiece to allow it to fit loosely in the centre without slipping out.

Front View

The feet are to be made out of rubber. These will probably be drilled and then attached by countersunk screws or bolts.

All the drawings on this page were created using SolidWorks. It is a computer programme designed to create 3-D drawings and is very useful. Once you learnt how to use it ,it can be very helpful in showing you what your final product will look like quickly and easily.

Side View

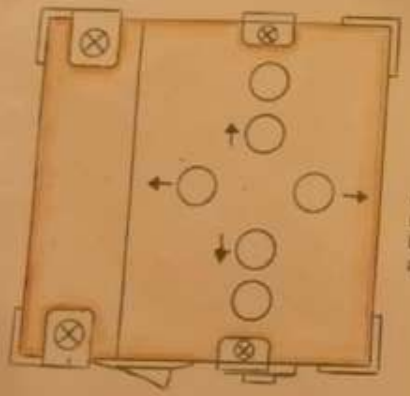
Final Development Page 2

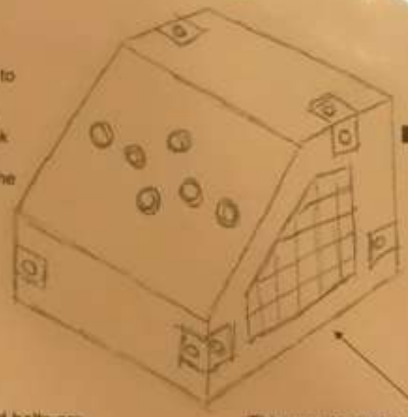
Using the programme 360° Photoview you can give any SolidWorks drawing a very realistic feel and make it seem real. these drawings were what confirmed that the design I was using was the right one.

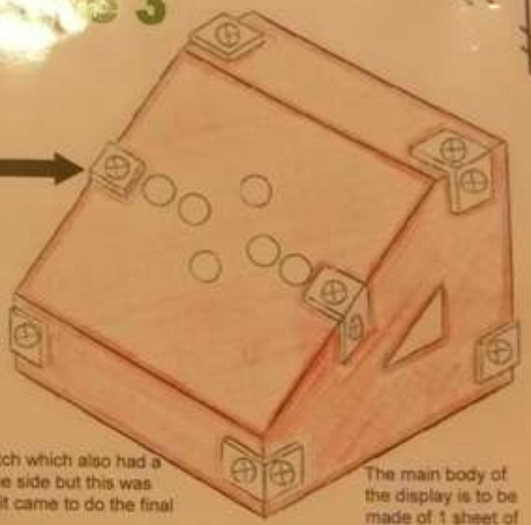
Final Developmen[illegible]e 3

The drawings on this page are all of the display and are hand drawn. The drawing below is an orthographic drawing with the main drawing on the right being done isometrically.

Brackets are used extensively in the display to hold the side panels on. Done properly they could make the final product look very well but if not made correctly they would ruin the rest of the product.



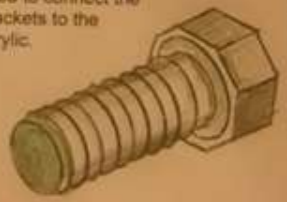




This was the initial sketch which also had a wire mesh design on the side but this was quickly removed when it came to do the final design on the right

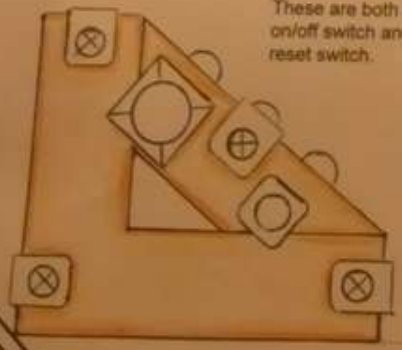
The main body of the display is to be made of 1 sheet of acrylic. This will be bent using a line bender to give the correct shape

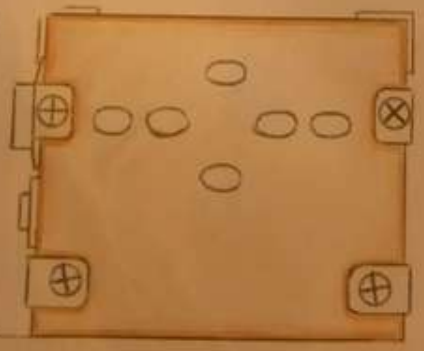
Nuts and bolts are used to connect the brackets to the acrylic.



Nuts and bolts are very useful as they aren't a permanent solution to sticking 2 things together. This means that if the circuit inside needs repaired or a battery needs replace it can done so without much mess.

These are both the on/off switch and the reset switch.





All the sharp edges will possibly need to be removed as this could cause injury. At the moment they make the product look very angular compared with the rounded image associated with the vane.

One possible switch that could be used. This particular switch is a toggle switch with 2 states, either on or off.

Plan of Manufacture

Circuit

• Print Design on acetate. This is the step from the virtual (on the computer) to the real.

• Using a specialist machine the design is printed on the PCB.

•Wipe the PCB board down with mentholated spirits to remove excess copper which affects the conductivity of the board.

• Once on the PCB holes are needed to insert the components. Different sized holes are needed for different components. 1.2mm is used for all terminal blocks, diodes and the 7805 voltage regulator. 0.8 mm is used for everything else, like the resistors, reed relays, transistors and the PIC.

• Obtain all components and make sure resistors and capacitors are the correct values.

• Insert all components into PCB and solder making sure that solder is correctly applied, connecting both the component and PCB board and not simply 1 or the other.

•Remove all the excess wire from the copper side of the PCB with the use of wire snips.

•All LEDs and switches entering terminal blocks need to be correctly soldered to wire and then shrink wrapped to protect both the component from harm and prevent sharp edges injuring the user.

Housing/Vane

•The first thing to be made should be the base for the vane. A mould should be made which is large enough to hold the input part of the circuit and wide enough to create a stable platform for the vane to spin and not topple.

•Indentations should made for the circuit to be attached and still leave a flush surface.

•This should then be vacuum formed and the piece of plastic being used should be removed from the rest of the plastic sheet.

•The hole to hold the upright of the vane should then be made. Holes for the insertion of the LDRs also need to be drilled, the holes should give a tight fit to the LDRs to prevent them slipping out.

•The upright should made of aluminium and be approximately 150mm in height and should be minimally smaller than the hole created in the mould so as to allow the vane to spin freely.

•A hole should be drilled in the top 3.5mm wide x 7.5mm deep to allow a rivet to connect both the upright and the arrow to each other without the need for glue.

•The arrow should made of wood, preferably a hardwood of length 120mm in length with the diameter 10mm.

•The tip should be also be made of hardwood of length 30mm but the diameter of one end should be 20mm tapered down to a blunt point at the other end. This is to be connected to the main part of the arrow via a male and female joint.

•The fin at the rear of the arrow is to be made of aluminium sheet and glued into place in a groove along the centre line of the main part of the arrow.

•A hole should be drilled along the centre of mass 3.5mm in diameter to allow the arrow to be attached to the upright.

•Next the disc with holes in it needs to be created. This has to have 4 slots in the shape of 2 arcs and 1 semi circle. The holes should be 14mm to allow light to completely cover over the LDRs. This disc is an integral part of the vane as it allows the circuit to distinguish between each direction the arrow is facing.

•The next thing to be created is the housing. This should be created out of coloured acrylic. A sheet should be bent into a rectangular shape with one corner missing. The ends should also be covered with acrylic which is attached with brackets to enclose the circuit.

•Holes should be drilled for the LEDs to fit and be visible along with holes for both the on/off switch and the reset to be accessed from outside the circuit. Holes to connect the circuit to the mould should also be made to prevent the circuit moving about with the housing.

•Finally rubber feet should be added on the bottom to give stability and prevent the base slipping about and prevent the acrylic being scratched. Feet should also be added to the bottom of the vanes base to give it extra stability.

Process of Ma[illegible]ure

Measuring the aluminium rod into lengths of 18mm.

Once measured cut with a hacksaw leaving space for error in cutting.

The spacer has a very rough finish which can easily be corrected with the use of the lathe.

The sides are [illegible] with large dents and scrapes. Again the lathe is used.

[illegible] lathe is used [illegible] have a high [illegible] finish to them.

The spacers all need tapped to ensure that the nuts will fit and hold the acrylic in place.

A design was drawn out on the CNC machine and a piece of acrylic cut to size.

The mould is drilled and sanded down to remove sharp edges.

The second step is to split the mould. Paper placed between the wood makes it easier to split.

For aesthetically purposes the mould had bits added to it.

The CNC requires constant supervision to make sure no errors are made.

The plastic case is then pieced together with the circuit inside.

Once the CNC machine is finished the disc needs carefully removed to prevent it snapping because of the tape on the bottom. The protective layer is then removed.

Finally it is attached to the base to make sure everything fits together neatly.

Once vacuum formed a piece of HIPS is glued to create a lip.

Make a model out of cardboard to determine correct measurements.

Create a design on the CNC machine to cut holes and letters and set it to work.

Adjust the size of the holes to allow LEDs and switches to fit.

Bend all the edges to 90° except face of display face.

File down edges for a better finish

Finally it just needed sanded to give it a good finish and glued to the upright.

Make sure circuit fits and drill holes to hold circuit in place.

Process of Manufacture continued

When creating the acrylic base I first had to measure out the correct size, this is the first attempt which looked too small but was then used to check the various other sizes required. The circles are the templates for the spacers and were also used to determine the centre of the circle for the countersunk holes.

This hole has been made using a countersink which helps leave a flush, flat surface once the nut is in place. It prevents the nut from snagging on anything nearby.

This hole has been these 2 pictures are of the base once it has all been screwed together. It shows that the spacers and the acrylic line up correctly. 3 holes had to also be drilled. 2 of these were for the LDR's and were 14mm wide with the other being the hole for the upright to go down through and this was 7.5mm wide and aligned in the centre.

The picture below shows the rounded corners that were sanded with wet and dry paper to give a smooth finish.

The LDR's placed in their holes. They fit snugly and don't fall out easily.

The point of the arrow was created with 2 small flat pieces of aluminium placed perpendicular to each other.

The edges had to be filed down as they were very dangerous before.

I cut a cross into the main body of the arrow [illegible] to be slotted into [illegible] glued in place.

The arrow was then pop riveted to the upright once both the arrow and upright had been sufficiently drilled.

I used a lathe to cut the upright from being wide at the bottom to being thin at the top to help weight distribution and aerodynamics.

East

The product is now complete with it all working correctly and the way it should.

South

This is the circuit in its North State with the inputs working correctly.

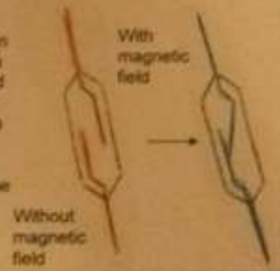
The arrow and upright were now complete.

West

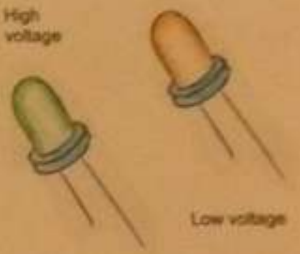
Modifications

There are a few improvements that would be made to my product if it were to be made again. This is due to the product being the first prototype and many unforeseen problems were encountered in the manufacturing of both the vane and the display.

The very first thing that should be change the LDR's used to magnetic reed switches. The reason LDRs were chosen in the first place is due to them being easily covered but as the project was started it became obvious that LDRS require a lot of time and effort in order to make them work. They took a long time to find the correct resistor to give the correct output. Also the LDRs would not work in dark conditions and always gave the direction of the wind to be West as this is the output when both LDRs are covered over. This problem could be sorted out by the addition of an LED acting as a light.



The second improvement would be to add an LED that shows whether the circuit is on or off. This would have been a very simple addition to the circuit and would have shown that the circuit was off when it had been switched off and not just a fault in the circuit. Shortly before the completion of the product a LED was found that would both show if the circuit was working but also show if the battery was nearly full of charge or whether it was nearly needing replaced by the change of colour from green to orange.

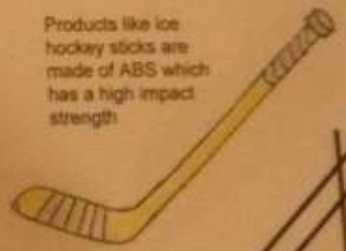


The fourth enhancement to the product would be the addition of a lightweight cage around the wind vane to stop the vane being knocked from nearby objects and also to protect and person or persons also nearby from being hit by the arrow which could maim or injure due to its high circular motion. However, a cage would have to use as little material as possible in order to prevent it from adding any inaccuracy to the direction the wind is coming from.

The third improvement to be made to the product would be a method of attaching the product and its display to its surroundings either by a clamp like system, suckers or by attaching shock cord to the base of each so it can connected and moved around easily. Included in the design was a means of stopping the product from slipping on inclines up to 25° but an angle any bigger than that and the product topples over. This improvement would prevent the product from falling overboard and being lost or damaged.

The fifth improvement that would be made would be the attachment or rubber strips to any edges of the wind vane base and also to the base of the display. This adds safety because there are less sharp edges to cut some body on. It also stops surroundings from being snagged on the edges and either being ripped or torn. A final reason for the addition would be to give the actual product protection from knocks and bangs from nearby objects which could potentially damage the vane or the display.

This sixth and final improvement to be made which would be to make any acrylic parts of the product out of a different material. Acrylic is very brittle and any hard knocks could crack it giving it less strength and stability. A good material to create this out of is ABS plastic. The reason acrylic was used is its high quality appearance, vivid colours and how easily it can be worked. Another reason for its use is the lack of ABS plastic in the workshop and the surplus of acrylic already there plus an understanding of how it can be worked was readily available.



Test and Evaluation

The initial test i did was to make sure that the product was able to quite happily sit on an incline of up to 25°. The product had rubber feet on the bottom of both the base of the display and the vane to help this. Without these feet the product would slip about very easily on the smallest of inclines. Both the vane and the display did this task quite easily but an incline any bigger than 30° and the product would just slip immediately. But as it was originally stated that the product only had to stay on a 25° incline the product did its purpose correctly.

The second point to be achieved was that the display would be able show the direction of the vane. This was tested with the help of a large sheet of cardboard. When the cardboard was placed between the vane and the display it was still obvious which direction the arrow was pointed. This was the main purpose of designing and creating the vane with a display that could be placed out of sight of the vane itself.

The price people stated the product at was higher than the raw materials used to create it and produced in an assembly line this product would be a viable business option that achieved all the goals it was meant to.

In terms of size the display was nowhere near the maximum size and it was still bigger than the minimum. This size constraint was to make sure it could fit easily onto a boat and not cause clutter or get in the way.
The vane was also within the size limits and was closer to being in the middle of the maximum and minimum values that the display.
The survey showed that people thought that the product was slightly too big but that wouldn't be hard mediate.

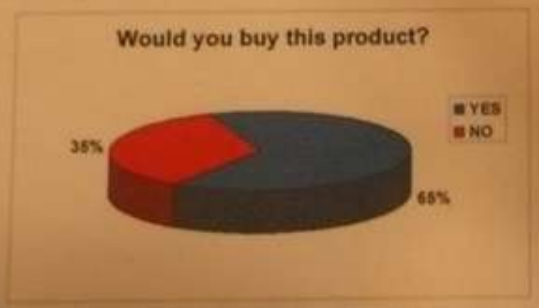
I created a survey which was handed to 20 different people that were walking on a busy high street. They were asked to complete it and hand it back in with the product being on display. All the results were positive proved that the product was a success. The average results of the survey are shown below.

Survey Questions (out of 10)	Average
Ease Of Use	8.7
Aesthetics	9.1
Quality Of Materials	8.2
Practicality	7.7
Size	6.3
Ergonomics	7.9
Accuracy Of Display	6.1

I also asked a few questions in the survey and the results where as follows

WOULD YOU BUY THE PRODUCT? 13 said yes, 7 said no
IF YES, WHY WOULD YOU BUY IT? One persons reason was that they had bad vision and this would be very helpful.
IF NOT, WHAT IMPOVEMENTS COULD BE MADE TO IT? 5 out of the 7 who would buy it said their reason was they had no use for a wind vane.
WHAT WOULD YOU PAY FOR THE PRODUCT? £78.31
ANY FURTHER COMMENTS? One person simply stated "keep 'er lit" but some serious comments were "well thought out" , "easy to use" and "slightly inaccurate".

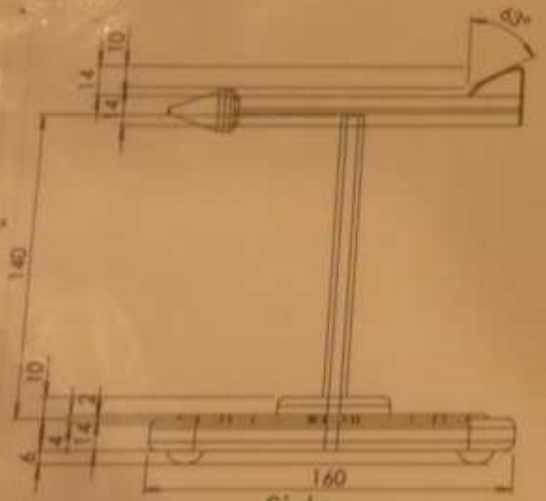
The reason that the comment "slightly inaccurate" was given because the circuit would have been made far more difficult that necessary with a lot more work needing to be done when it was not required. This product was a prototype to show a vane could be made with the use of LDRs as a means of reading the wind direction and has proven that it is entirely possible.



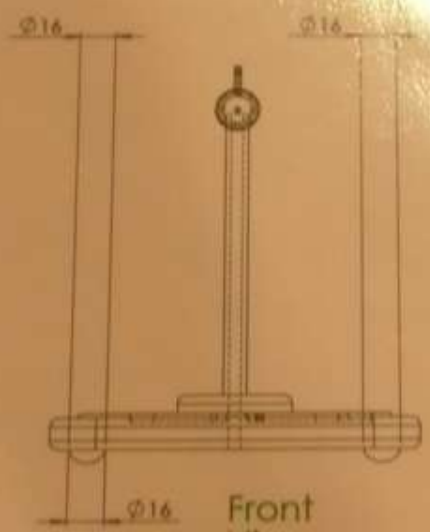
The pie chart above displays the results from the question "would you buy this product"and the majority said yes.

The graph above shows the average results of all the questions asked in the survey and it shows that the product was very successful in a number of key areas.

orking Drawing

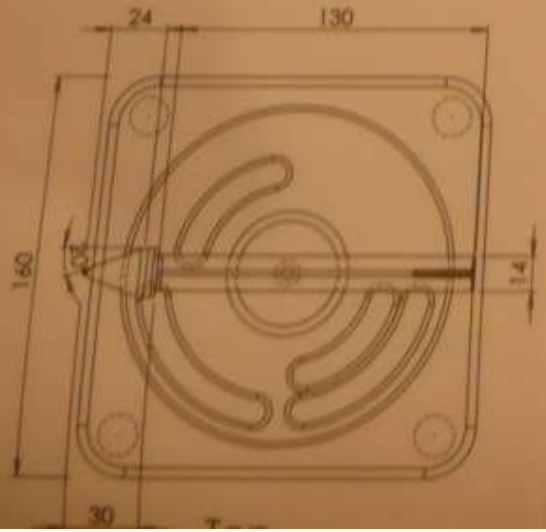


Side View

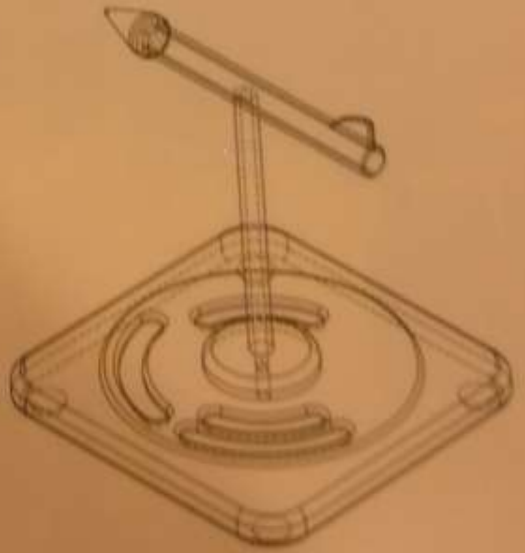


Front View

These working drawings are a scale of the finall product. each of the measurements on this page is twice that of the actual working drawing measurement. this gives the working drawing a scale of 1:2. if the working drawing was the same size as the final product it qwouldnt fit onto 1 page.



The working Drawings give me something to refer back to when i am making my product.



Orthographic View

Changes Made During Manufacture

This is a list of changes made during the manufacture:
The first significant problem was creating a base that was large enough to give a stable platform but also structurally strong enough to not bend or crack in the middle with the weight of the arrow and upright once the holes had all been drilled. The vacuum formed plastic was very weak so a different type of base was needed. This was created out of 2 sheets of acrylic with aluminium spacers which had been tapped to allow bolts to hold it all together. This had been made to make sure there was enough room for the circuit to fit in. due to this drastic change a different mould had to be created. This mould would be a lot smaller than the original mould as it just had to hold the circuit which had been made to be as small as possible.

The second change was in the arrow. Instead of creating it out of wood, the way it had been specified in the plan of manufacture, it was now created out of aluminium. The reason for this change was the accuracy and aesthetics of the arrow. If the wood were to get wet it would warp and reduce the accuracy of the arrow. Aluminium does not warp when wet so the decision to change the material was made. The arrow also looked more aesthetically pleasing when made out of aluminium rod instead. The tip of the arrow was also made out of aluminium for the same reason. The fin at the back was changed slightly. It had 3 other fins added to be in keeping with the 4 pronged arrow at the front.

The third change was carried out on the display. This too was to be an enclosed unit but instead the design was changed. The ends were taken away and now it had open ends. This now meant a mould had to be created to keep the circuit secure. This was made out of vacuum formed plastic the same as the mould for the input circuit. The circuit was then safe from knocks

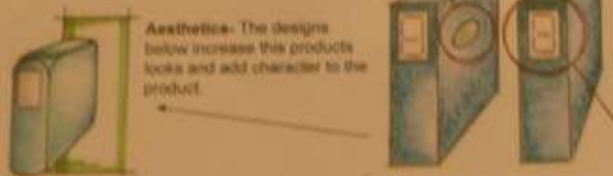
Input | Process | Output

Initial Ideas 1

Below I have designed a number of different gateways for the counter circuit. They provide more style and character to the product. I have designed them in a way that the anthropometrics match the average waist height, therefore as the person walks past the LDR detects this and the resistance decreases. The designs look more aesthetically pleasing yet at the same time the ergonomics of the product work well and efficiently.

Laser micro switches will be situated here, as the person walks past they will brush past the micro switch and trigger the circuit

Ergonomics- I believe that the micro switches greatly add to the workings of the product. They are easily activated yet effective at what they do.



Aesthetics- The designs below increase the products looks and add character to the product.

LED's (light emitting diodes) are polarised components and must be connected round the right way. Common cathode LED display will be connected to the negative rail, common anode is connected to the positive rail. LED's come in different colours such as, Red, yellow and green. Seven segment displays need a decoder to produce the correct numbers 0-9.

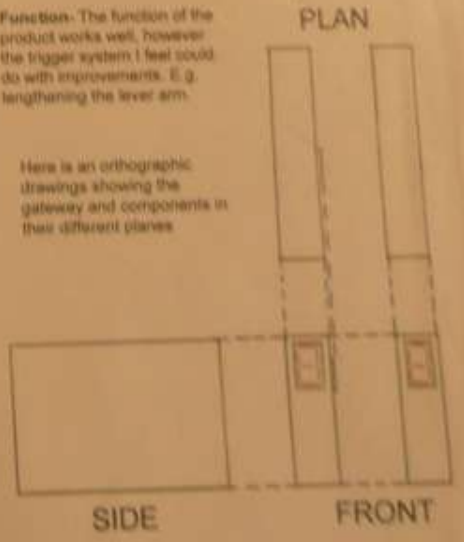
On evaluating the product with the aesthetics and ergonomics are simple however the design is slightly bland and boring. The LED displays and LDR's would sit flush instead of slightly protruding from the finished product. I would make the edges curved as I've shown in my design for safety of younger users such as children.

Overall I would rate this product around 6/10.

The main body or frame of the product will be made from aluminium or stainless steel. Both metals provide durability, strength and can be easily bent into shapes. Also the metals can be finished in such a way that it provides a stylish sleek look. The housing for the LDR will be made from Urea Formaldehyde as this plastic has physical properties of high hardness and toughness, which makes it suitable for knock-resistant electrical fittings, it is also a good insulator, a prime safety factor required.

Function- The function of the product works well, however the trigger system I feel could do with improvements. E.g. lengthening the lever arm.

Here is an orthographic drawings showing the gateway and components in their different planes



This design to the left looks similar to the main design, however it is taller and thinner. I included this for people who are taller than the average anthropometric height suggested.

Circuit Idea 2

Input

The input to this circuit is controlled by a voltage regulator and two PTM (push to make switch). As one switch is pressed it triggers the up or down phase. Therefore when one person walks through the turnstile they will push the switch causing a pulse to pass into the 16F627 pic.

The voltage Regulator is a electrical regulator designed to maintain a constant voltage. Can be used to regulate both AC and DC power supplies.

Process

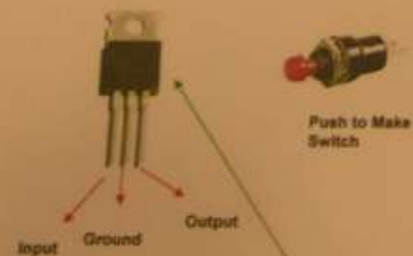
The process of this circuit is controlled by a 16F627 PIC. The PIC is represented by an 18 pin DIL in this circuit diagram. The PIC will be programmed so that every time it receives either an up or down pulse from the inputs it will count up/down by one. As switch 1 is pressed it counts up and as switch 2 is pressed it counts down.

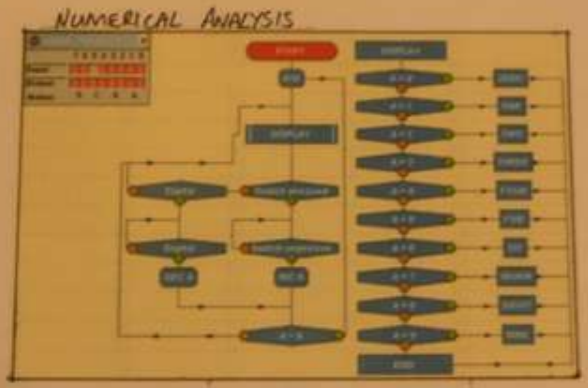
The PIC program is shown below.

Output

The output for this circuit is a seven segment display. It receives the decoded pulses from the PIC and therefore it lights up the corresponding bar on the display. These bars are LED's so they require a 330R resistor connected to each one. The 7-segment display can be connected directly into he output pins of the 16F627 chip as it already has the decoder inside it.

The alternative for using a LED display could be a bargraph display, we could use each segment and count it as one. So if we had a display with 10 sections the it could count up to 10 people.

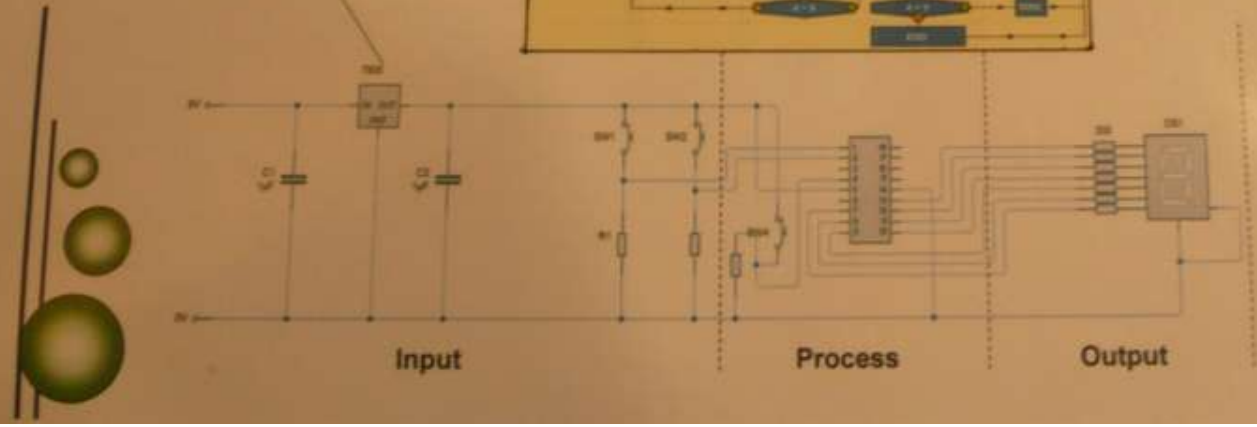




The PIC flowchart works as follows. As input is 0 the circuit will count up, and when input 1 is active the device will count down. The 7-segment display is connected directly into the PIC's output pins.

Components needed to create circuit.

- Vo[illegible] which [illegible] 7805
- 2x P[illegible]
- [illegible]
- 16F627 [illegible]
- 7-Segment Display



When reviewing this circuit I don't think it will be reliable enough to carry out the everyday demands that it is required of. It may need re programming at times if things get faulty. Therefore I will rate this circuit:

5/10

Initial Ideas 2

segment is in an easily visible place.

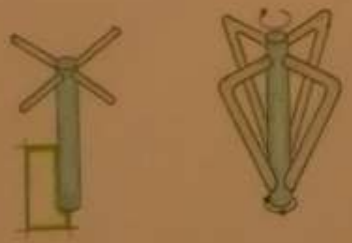
Overall I would rate this product **8/10**

My second idea is a form of turnstile. This turnstile is mounted to the main frame. It is a simple and effective method of counting people in and out of buildings without any manual assistance.

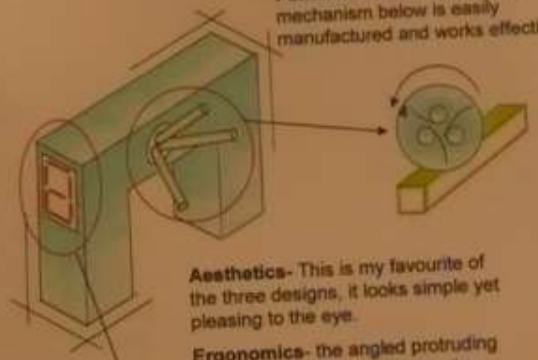
The main frame of the body will be made from aluminium. This provides strength and structure to the turnstile, Aluminium is also very durable yet reasonably cheap to get hold of. Aluminium is very ductile, soft, malleable, machines well and very light.

This is a small [illegible] regulator which [illegible] regulated power [illegible] it helps lowers voltage [illegible] low currents, reducing the [illegible] electrocution.

Below I have designed two different turnstiles that could be used. They both are externally attached from the main frame but are still connected to the same circuit. Both the stiles main shaft will the manufactured from stainless steel, stainless steel provide a strong base which is resistant to rust and very tough. These properties could allow for the product to be situated in an outdoor environment, perhaps the likes of a football stadium etc.



Function- The function of the mechanism below is easily manufactured and works effectively.



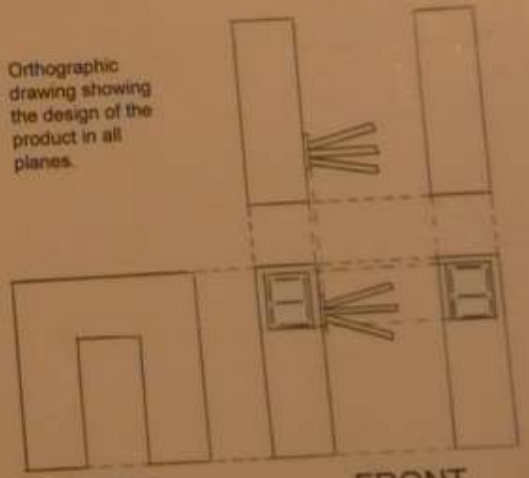
This is the mechanism I designed so that every time the stile is rotated it clicks a micro switch producing a pulse.

PLAN

Aesthetics- This is my favourite of the three designs, it looks simple yet pleasing to the eye.

Ergonomics- the angled protruding legs allow for easy activation, they are designed in such a way that when one person passes through there is another leg waiting for them to push through.

Orthographic drawing showing the design of the product in all planes.



SIDE FRONT

For both these stiles for them to connect to the circuit they could have either a variable resistor, potentiometer or a mechanism that clicks a micro switch every time the stile is turned. This would create a pulse into the counting chip and display a number on the seven segment.

To the right is an alternative to a seven segment display. The bargraph could be used so that every time a person passes through the turnstiles a segment on the bargraph will light up. Each segment would represent one person.

Circuit Idea 3

Input

The inputs on this circuit are three potentiometer. Potentiometers are basically a voltage divider. As the meter is turned the resistance changes and therefore the voltage flowing through the circuit is different.

Potentiometers are commonly used to control electrical devices such as volume controls or in some cases used in joysticks.

There are two types of potentiometers. Linear potentiometers or rotary. The type I will be using are rotary. This will be applied to the product so that every time a person walks through the turnstile they change the resistance by turning the potentiometer and turnstile at the same time. This produces an output signal.

Numerical Analysis

$V_o = (R2/R1+R2)\,V_i$

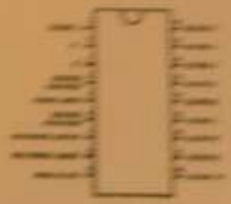
This is the calculation for the potentiometers as a voltage divider device.

Here is a linear potentiometer, it is the alternative to a rotary one but for the purposes of my product I will be using a rotary as potentiometer and it provides the more desirable motion required.

1 ceramic radial capacitor can be used to prevent DC current passing through the circuit, yet allowing AC current to flow through the circuit.

Process

The process in this circuit is controlled by the LM391x driver. This provides the decoded signals from the potentiometers to the bargraph display. The driver produces outputs to drive the 10 LED's present in a bargraph. It can drive LED's of many different colours and of different voltage levels. The LM391x regulates the voltage being supplied to the bargraph therefore no need for resistors compared to the Seven-Segment display which needs seven resistors.



Output

The output which is connected to the LM391x is a bargraph display. It consists of 10 LED's which light up according to the resistance of the potentiometers. As you can see the potentiometer ('P') has increased by 30% and has put 6 of the LED's on, on the bargraph.

If an analogue signal is fed into the display driver the number of LED's lit increases as the analogue signal voltage increases.
If the analogue input signal voltage is 0V then no LED's are on.

Input

Process

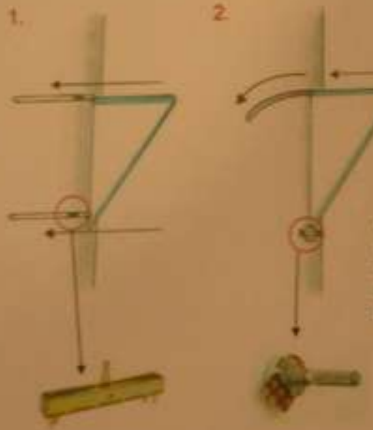
Output

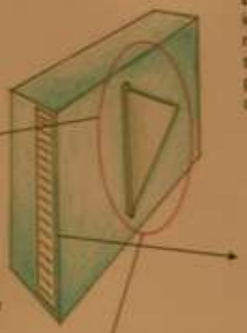
Initial Ideas 3

Below I have designed to mechanisms involving a rotary potentiometer and a linear potentiometer. Idea 1 uses two linear potentiometers, as the person slides the glass or Perspex back into the frame they are pushing the potentiometers at the same time, this causes a change in resistance in the circuit therefore lighting up another segment on the bargraph. Idea 2 involves using a rotary potentiometer which is situated at the bottom of the glass. As the person pushes the top of the glass into the frame the rotary meter changes resistance and makes another segment light up.

When reviewing this design it looks aesthetically pleasing with the clear glass acting as a gate and the brushed aluminium finish on the framework, but also it is ergonomically good, the glass gates are perched on rails so the pushing of them can be made easier with little effort required.

Overall I would give this product **7/10**

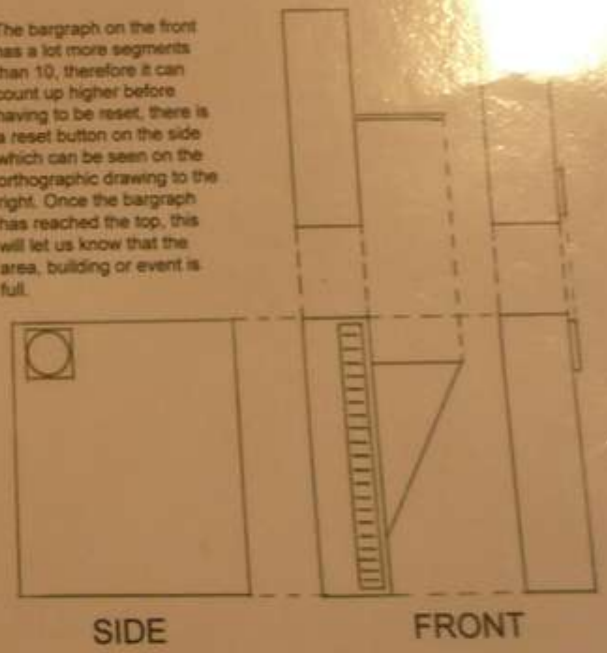




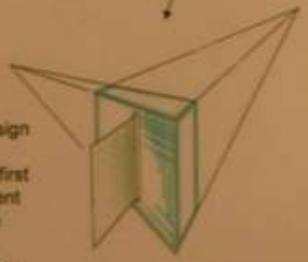
Ergonomics- The sliding glass is a good idea and works well with precision manufacturing, however to achieve this in the school workshop it could be difficult. The potentiometer also can be temperamental if it doesn't get enough rotation

Aesthetics- I feel the looks of this product are good, again simple but easy on the eye.

The bargraph on the front has a lot more segments than 10, therefore it can count up higher before having to be reset, there is a reset button on the side which can be seen on the orthographic drawing to the right. Once the bargraph has reached the top, this will let us know that the area, building or event is full.



To the right I have designed an alternative design for the glass or Perspex gate. This design provides more of a barrier than the one in my first design and therefore causes more of a deterrent for anybody passing through who shouldn't be passing through. This gate would have to use slide potentiometers as tehre is no rotary action being produced.

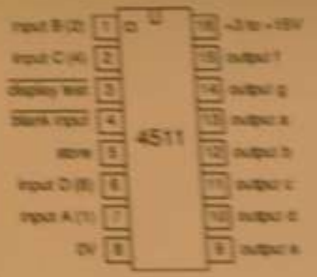


Circuit Development

The 4510B chip. Also known as a BCD updown counter. BCD (Binary Coded Decimal). The chip contains four outputs capable of counting up or down, requires a clock pulse to do this though.

My PCB designs transferred onto the protoboards. In this picture they haven't been drilled. When drilling them every component is drilled at 0.8mm whereas terminal blocks are drilled at 1.2mm.

The 4511B 7-segment decoder driver is to convert the logic states from the outputs at the 4510 and create signals which will drive a 7-segment, shows number from 0-9.



Below is the board that controls the UP/DOWN element of the circuit, as this switch is pressed it changes from either up or down.

Picture showing when the micro switch is pressed the 7-segment counts up 1 or decreases by 1. I've only shown one 7-segment because when I connected the other one up the number jumped between each other.

Here is the two 7-segments beside each other with numbers displayed on them, at the moment the circuit is in the up position, so the numbers increase.

This is the datasheet that goes along side the 4510B, it help you connect the chip up with other components and breadboards.

Compared to the above picture the on to the left is in the down position as it is now at 15. It went from 17 to 15, this was achieved by flicking the SPDT switch.

A final picture of the circuit fully working, the reason for the numbers jumping was a small bit of solder cross tracks on the monostable circuit.

Calculations

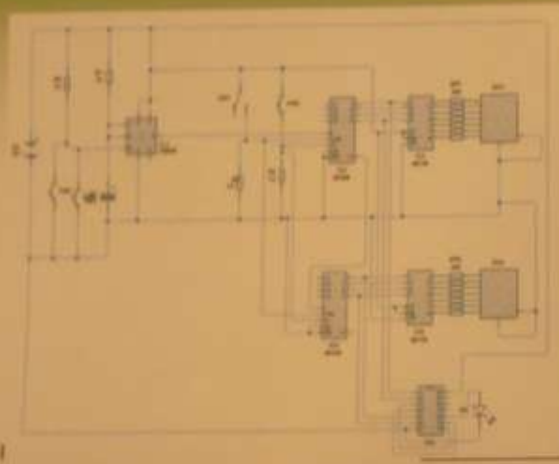
The output timing for the 555 monostable circuit is calculated by the equation below.

Tsec= 1.1xRxC

R= Resistor

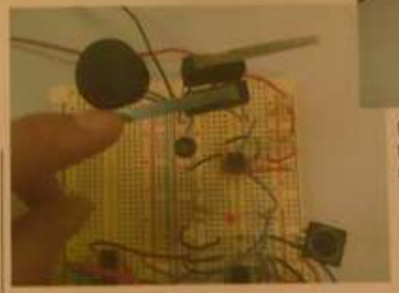
C= Capacitor

Circuit Development



Above is the circuit designed with a NAND gate incorporated in it. In the later stages I decided to take this feature out. As you can see the 7-segments are driven by the 4510B and 4511B chip, while the 555 monostable is producing an input pulse for the chips.

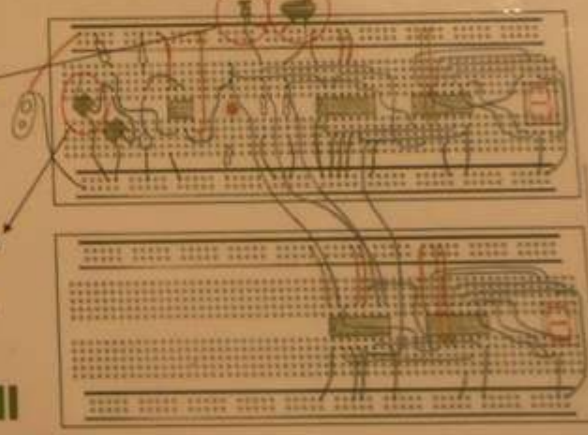
To the right is my working protoboard. As the micro switches are pressed they provide a pulse into the 555 which sends a signal out to the 4510B chip.



This is the input process of the circuit. It is a 555 monostable. Providing a pulse for a set amount of time.

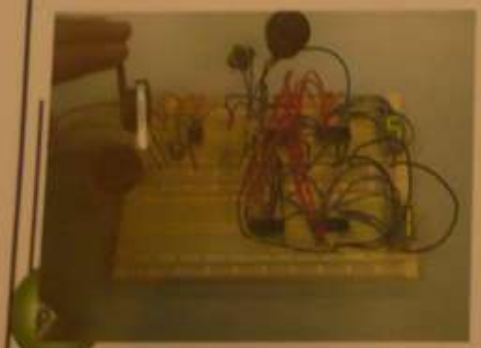
NAND gate switching on the LED once circuit reached 99.

This switch controls the UP/DOWN counting. It's a single pole double throw SPDT



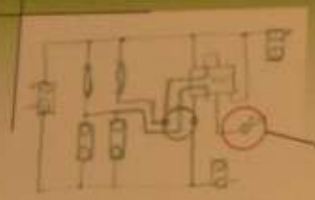
This is the reset and is a PTB switch. It is linked to both 4510B chip so that it resets both 7-segments at the same time.

These are the input micro switches. Either one can be pressed to provide a pulse.



When I had the circuit all wired up on the protoboards the NAND gate was very temperamental in its operation and for this reason I decided to take it out of the circuit altogether.

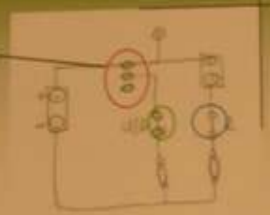
Circuit Development



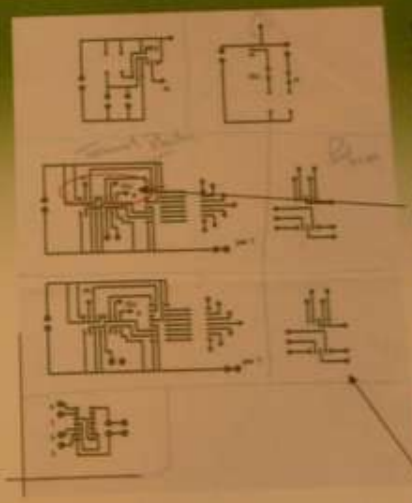
This is the input to the circuit. I have designed the 555 monostable in PCB format. The tow terminal block beside each other will be used to connect the switches to the board.

This is the SPDT switch. Used for the UP/DOWN

The clock output which provides the pulse to the 4510B chip.



This part is will control the UP/DOWN part of the circuit. It will also be used to reset the circuit.

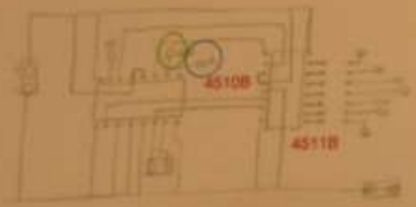


My PCB board designs, which needed tweaked and changed before a final PCB page was produced.

I had to put terminal blocks in the U/D, clock and reset tracks instead of using pads.

Another modification that was needed was to increase the pad sizes of everything. This helps in getting good connections.

After doing a bit of testing with this 7-segment pcb design I discovered that not having terminal blocks was a real hindrance, therefore I used my second pcb design shown previously in this page.



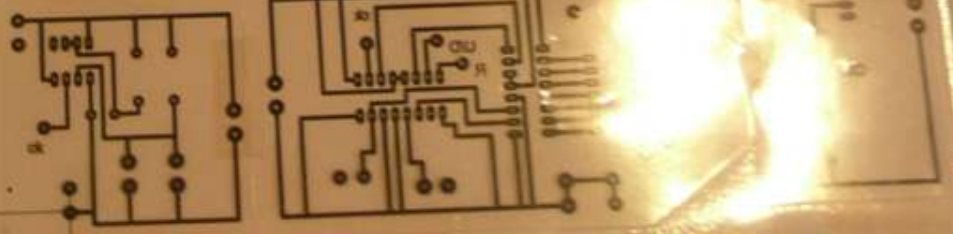
This is the first of the two main circuit boards. Pin 7 on the 4510B is the carry out which will connect to pin 5 (carry in) on the other 4510B on the second circuit board.

After connecting the NAND gate on the breadboards I decided to take it out as its operation was very temperamental and usually didn't work.

The Final PCB designs on acetate, ready to be manufactured onto protoboards.

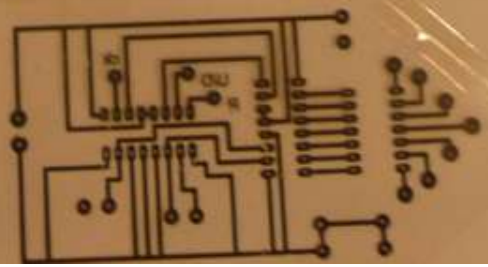
The circuit below is the same as the one above however it has a terminal block connected to pin 5 to allow for the carry out from the first board to enter the carry in on this board. Pin 15 on both are the clock. This is where the pulse from the monostable will enter.

Below I have designed two possible track arrangements for the 7-sgement display. For my circuit I will use the design to the right. All the connections will be made with terminal blocks to allow easy wire changes.



1st design

2nd design. Ended up



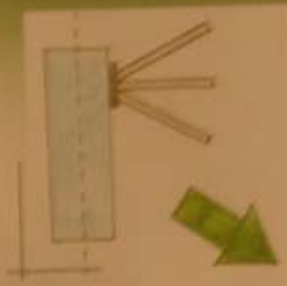
Concept Development 1

This design shows you where the reset for the circuit will be positioned, it too will have a rotted out hole for the HIP (high impact polystyrene) plastic to form around.

Above is a tactile micro switch, this is the type of switch I will use for my reset in the circuit. It is a PTB switch which means when its pressed the connection between the two contacts of metal is momentarily broken, therefore current can not pass through the circuit.

When designing my idea I thought this initial design was the best of the lot. To manufacture this product I had to make a few adjustments to allow the circuit to fit and work.

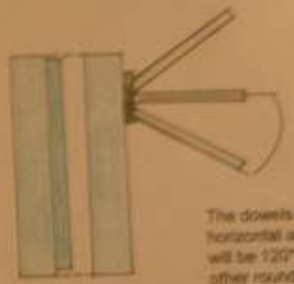
Function- By inserting this small tactile PTB switch the reset can be easily operate with minimal effort. Also it is positioned in a very easily accessible part of the product.



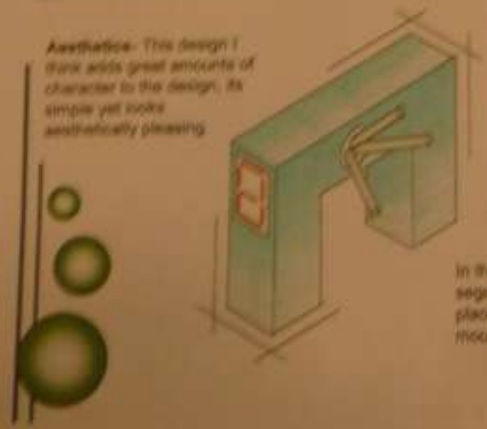
Once the moulds are made they will have to joined together. This is achieved by gluing a 1cm wide piece of HIP round the inside edge of the mould, this will act as a lip for the other mould to cover.

When designing the aluminium pins coming out from the rotating mechanism, it will be very hard to get the correct angle out on one end of the dowel to allow for this shape as below. This could be done by cutting it with a hacksaw at a measured angle, then sanding and filing it out to the required angle.

Ergonomics- The angle of the protruding legs adds to the ergonomics, as when one is pushed through there is another waiting for the next person, the three legs will each have a trigger on the other side of the mould.



The dowels will be 45° from horizontal and the three legs will be 120° apart from each other round the rotating base.



Aesthetics- This design I think adds great amounts of character to the design, its simple yet looks aesthetically pleasing.

This is will be the general shape of the turn stile, the extruded cut out of the middle of it provides it with good aesthetic qualities. It will have a hole drilled out just above the centre section which is where the rotating mechanism will go.

In this initial idea I will not be putting the 7-segment in in the mould, instead they will be placed in a different mould separate from the moulds.

Aesthetics- This design enhances the looks of the product, the cut away adds another dimension and character to the product.

Concept Development 2

As I am making a scale model of these products they will require a base section. Here I have a couple of design ideas.

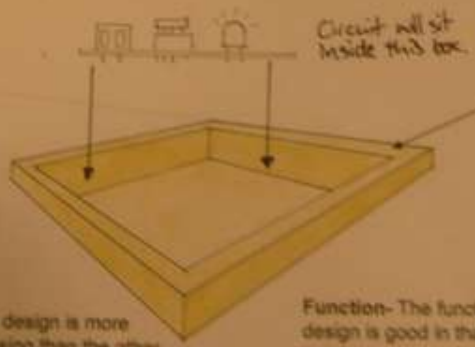
Ergonomics- The ergonomics of this design I feel are good however the aesthetics of it do not compliment the product in any way.

This design is simple and hides all wire when the product is finished. The 4 holes will be drilled out, these holes will provide an area for the circuitry wires to run through and to the turnstiles.

The holes on the bottom of the turnstile will line up with the holes on the base below. The turnstile would be secured down with self taping screws.

In order to house the circuit underneath the main base, I will have to make a separate HIP box, this will be vacuum formed round a mould. For the base to sit steady and still I will have to make four legs out of aluminium, all the same length and width for aesthetics.

Above shows how the drilled holes will line up with areas milled out for wires to run through under the base.



Instead of having a model standing on four legs I designed a base which has a square section milled out. This section is milled down far enough to allow my circuit to sit in it. It has to be deeper than the standard size terminal blocks.

If I use the desi… milled out, I will also … and the outside. Thi… place a piece of … circuit. This is also … partition will be situated … the final product.

Aesthetics- This design is more aesthetically pleasing than the other designs, it integrates the circuit within it hiding all wires from the outside world.

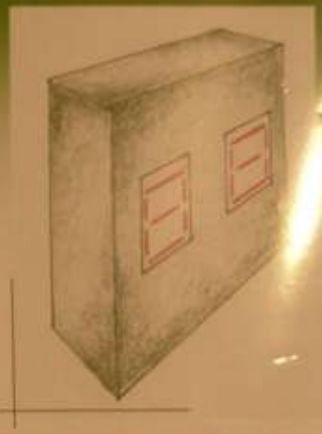
Function- The function of this design is good in that it carries out its job in covering the circuit adequately.

Concept Development 3

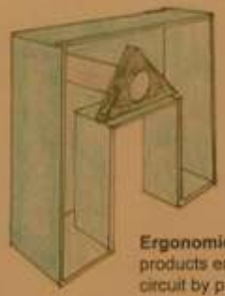
This is a picture showing how I will make the rotating mechanism which will trigger a switch and create a pulse going into the 4510b chip.

Aesthetics- The aesthetics aren't really increased by this concept as this will be hidden by the other side of the mould

This is the design I am hoping to use to house the 7-segment displays. To add to the products aesthetics I will create a black acrylic surround. This will hide any rough edges from the cutting away of the HIP plastic.



By putting this triangular shaped cam on the end of the dowel, every time the turnstile is turned the triangle acts like a cam, in that as it rotates the protruding corners of the triangle it will pass past a roller switch triggering the circuit.



Ergonomics- This design will increase the products ergonomics as it will trigger the circuit by passing past a roller micro switch.

Aesthetics- This I feel doesn't add to the aesthetics of the product as its bulky and doesn't flow with the product.

Function- This design adds to the operation of the product, the traingular cam will trigger the switch which in turn creates a pulse going into the 4510B chip.

This is where the micro switch will be mounted, it will positioned here so that you can only push it in the forward direction. If you where able to walk through the turnstile the wrong way it wouldn't be doing its job correctly.

Here I have shown how deep and wide the reset switch housing should be. I also have to take into account that the HIP plastic will take up about 1mm around the mould. I have taken this into consideration and made the whole slightly bigger to accommodate this.

Ergonomics- This I feel adds to the ergonomics of the product. The reset switch will be small and flush with the mould. It is also easily pressed and accessed.

Plan of Manufacture/Manufacturing

A guide to the stages I will progress through to manufacture my product.

Stage 1: Design a suitable circuit for my product. I will use computer programs like livewire and circuit wizard to assist me in this.

Stage 5: Using the CNC Machine I will accurately cut out a rectangular hole in my base where the circuit will be housed.

Stage 9: Once I have my manufacturing done I will revert back to my circuit. Here I will measure the lengths of wire required to go from circuit board to components. These wires will then be shrink wrapped so there's no live connections showing.

Stage 10: For an aesthetic addition to the product I will create a centre partition, this will be made from blue transparent acrylic. The spacing for the partition will be determined by aluminium spacers which I will create using the lathe, these are then pop rivetted into place.

Stage 2: Once I have my circuit working on the computer I will begin to build it on breadboard. From here it will be converted onto PCB wizard, this process prints the circuit onto protoboards with copper tracks.

Stage 6: When I have the moulds complete the next step is to drill the necessary holes for the electrical components to sit in.

Stage 7: When my circuit is in place and secured to the wood I will cut out a blue acrylic insert that will go over the top of the circuit. The CNC machine will have created a lip for this to rest on. This acrylic sheet will be 18.5 long and 14.5 wide to cover the gap.

Stage 3: The components are then soldered to the circuit. Sanding down the edges will help aesthetics of the circuit.

Stage 8: Another thing to be made is the turnstiles will be the making of the mechanism that clicks the micro switch once the turnstile is turned. They will be made form black acrylic and mild steel. I will create a triangle like cam on the inside of the mould which will trigger the circuit.

Stage 4: Once my circuit is working I will design a suitable product for the circuit to fit into and work properly. To do this I'll have to make MDF moulds which will be vacuum formed.

These are the finished moulds, made in blue HIP plastic which is suitable for vacuum forming. The mould has a HIP insert to create a lip for the other side of the mould to secure over.

Stage 11 : The MDF [illegible] base will be painted [illegible] stage all the components [illegible] be complete. I will then begin [illegible] put the whole product together.

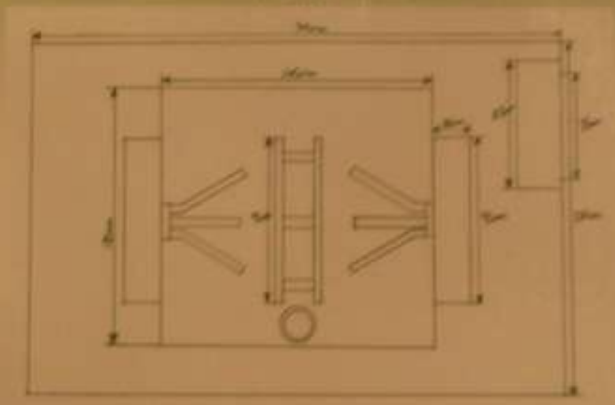
Working Drawing

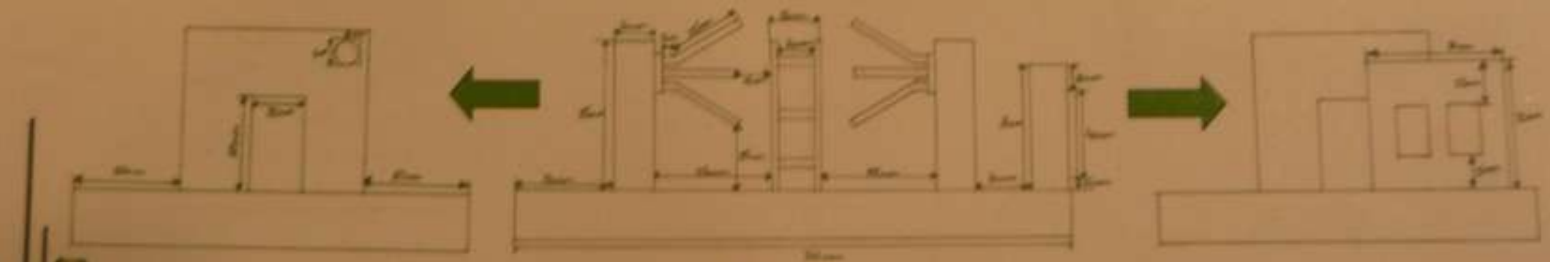
Working drawing showing all dimensions from plan, front and both sides. The drawing has been drawn down to scale however the dimensions are all the final size.

MATERIALS USED.

Base = MDF
Turntables = Blue HIP plastic
Rotating mechanism = Black acrylic
Mild steel
Circuit cover = Blue Acrylic
Partition = Aluminium spacers
Transparent blue Acrylic

Plan





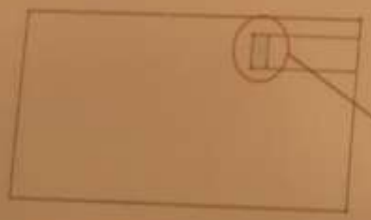
Front

Changes made During Manufacturing

Throughout the manufacturing process I made a few changes to accommodate for some technical issues.

One of these changes was using Roller micro switches instead of lever. This was due to the fact that when the lever switch was triggered in created a bounce affect which jumped numbers on the 7-segments. Also the roller switch work better with the triangular cam inside the and it followed the contours better.

Another change included milling a small section out from underneath the base. This allowed me to run the 7-segment wires from the display housing to the main circuit board. By doing it underneath it was hidden from the human eye and kept the neat and tidy finish flowing.



Hole for wires to run through

Having somewhere for the 7-segments to be placed was proving difficult, to solve this I created another vacuum formed mould to house them in, this isn't how I wanted the product to look however we were limited to the manufacturing processes and this was the simplest to do.

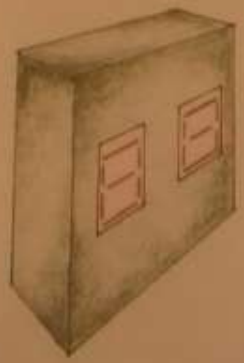
Future Modifications

If I was to do the product again I would make number of changes to the design and the circuit.

A change I would make to the circuit would be to design a circuit that would count up or down on its own free will. At the minute I have to flick a switch to count up or down, which in different situations could become a nuisance.

When fitting my circuit into the base I discovered that the amount of room to work with was very tight and cramped, if I was to do it again I would CNC the gap further into the base. This would allow for easier installation of circuit and components.

Another modification I would propose would be to have the 7-segments integrated into the wooden base. This would mean two holes would have to be milled out to accommodate for the size of height of the display.



Here you can see how I would propose to put the 7-segments into the side of the base.

Testing and Evaluation

Now that the product is complete I have it has to undergo a testing and evaluation process. The product will be tested against the design specification. Throughout the process the product may have had slight changes, this will be highlighted here.

Ergonomics: The ergonomics of the product are good and work well, the three protruding legs are designed in a way that when they are turned they create a trigger to the 4510B chip. Also the rotating mechanism is good as you can't rotate it in the opposite direction, a vital component in turnstiles.

Aesthetics: The aesthetics of the product compliment it very well, the HIP plastic with the gloss finish provides a strong stylish look, while the black acrylic of the mechanism and the mild steel contrast nicely with each other. The circuit cover is made from blue acrylic with the centre partition glued to it. The finish of this keeps the blue look running through the product. Also the design of the turnstile with the extruded cut gives the product character.

I ran a small survey to see what people think of the finished product. The results are shown here. Out of twenty people 18 people liked it where two of these people said there could have been improvements. These improvements included colour and shape.

Safety: Does the product meet required standards? Yes the product does, I have improved the shape of it by rounding off the edges and filing down the Sharpe ends on the protruding legs.

Also in the circuit any components that had to run into the turnstiles the wires were shrink wrapped around the live wires to prevent electric shock.

Materials: Comparing to the first specification I have changed a number of the materials, instead of using acrylic to make the moulds I used HIP vacuum forming plastic. I used this as I was able to form it round moulds I made earlier in the process.

Instead of using aluminium for the protruding legs I used mild steel as it has better properties. Its stronger, more durable and will last a lot longer in an everyday situation.

Instead of using MDF for the 7-segment housing I used black HIP, The reason for this was that making a wooden housing wouldn't have a aesthetically pleasing finish.

To the left is a survey of the suitability of the materials.

Function: As this is a counting circuit it is ... circuit doesn't jump numbers. As this co... reading on the amount of people entering ... building. When I asked people about what they ... of the product a number issues arose, ... that the product would never be able to ... place as the materials used where not ... strong enough. If this was made to a 1:1 ... product would be made from different ... stainless steel and aluminium.

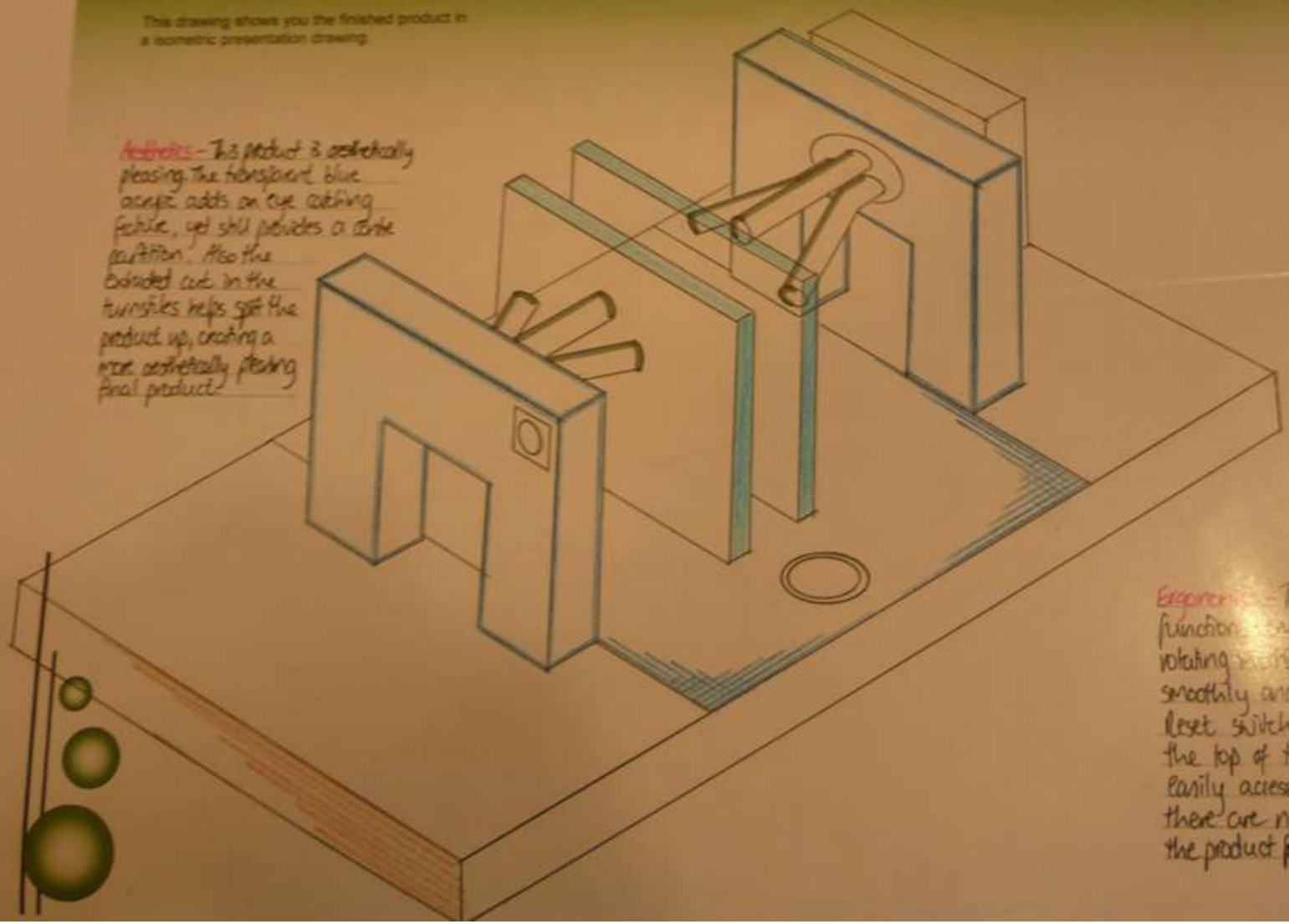
The product is operated by two turnstiles. ... turned the triangular cam on the inside of the ... triggers the micro switch, this ends a pulse to ... chip and 4511B. This increase or decrease in ... shown on the 7-segmenst.

Performance: This refers to the circuit within the product. Does it carry out the required needs? In the specification I said that the product will be operated by LDR's, however this is not the case, I changed the circuit to using micro switches as they gave me a more positive pulse. These micro switches are suitable for the product as the triangular cam can easily activate it.

Overall I think this product has turned out very well, it carries out its job perfectly and is aesthetically pleasing, also the ergonomics of the product compliment the manufacturing of the product.

Presentation Drawing

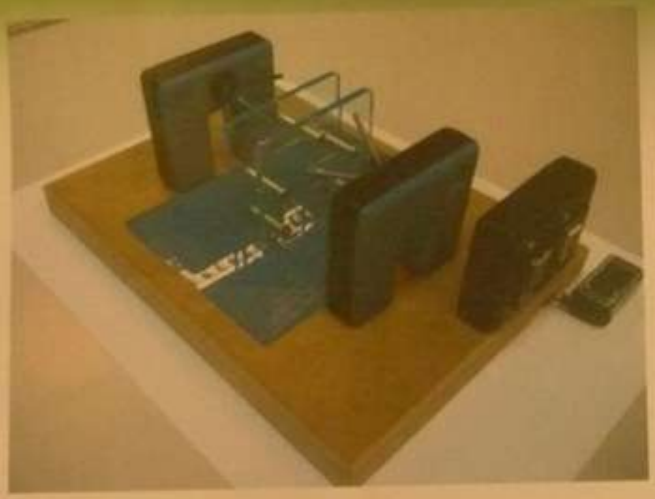
This drawing shows you the finished product in a isometric presentation drawing.



Aesthetics - The product is aesthetically pleasing. The transparent blue acrylic adds an eye catching feature, yet still provides a finite partition. Also the extruded cuts in the turnstiles helps split the product up, creating a more aesthetically pleasing final product.

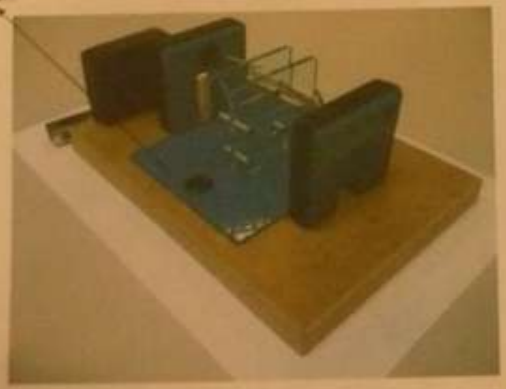
Ergonomics - The product is functioning very well, the rotating mechanism operates smoothly and efficiently. The reset switch is positioned on the top of the turnstile, it is easily accessed there, also there are no sharp edges on the product for safety reasons.

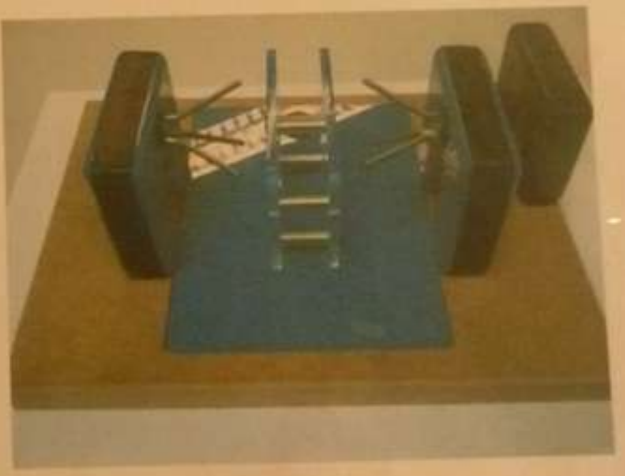
Final Product

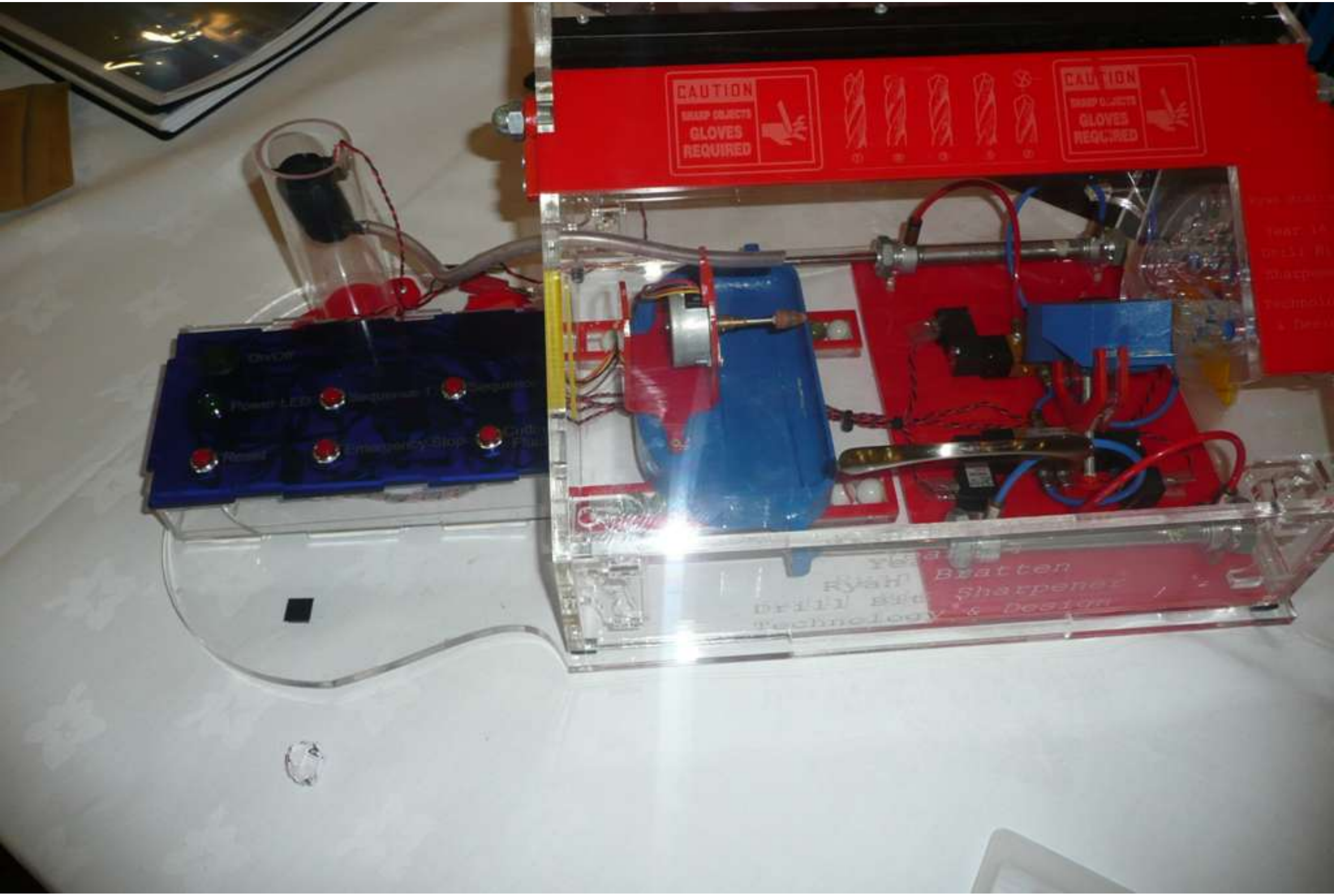


Reset switch

UP/Down switch

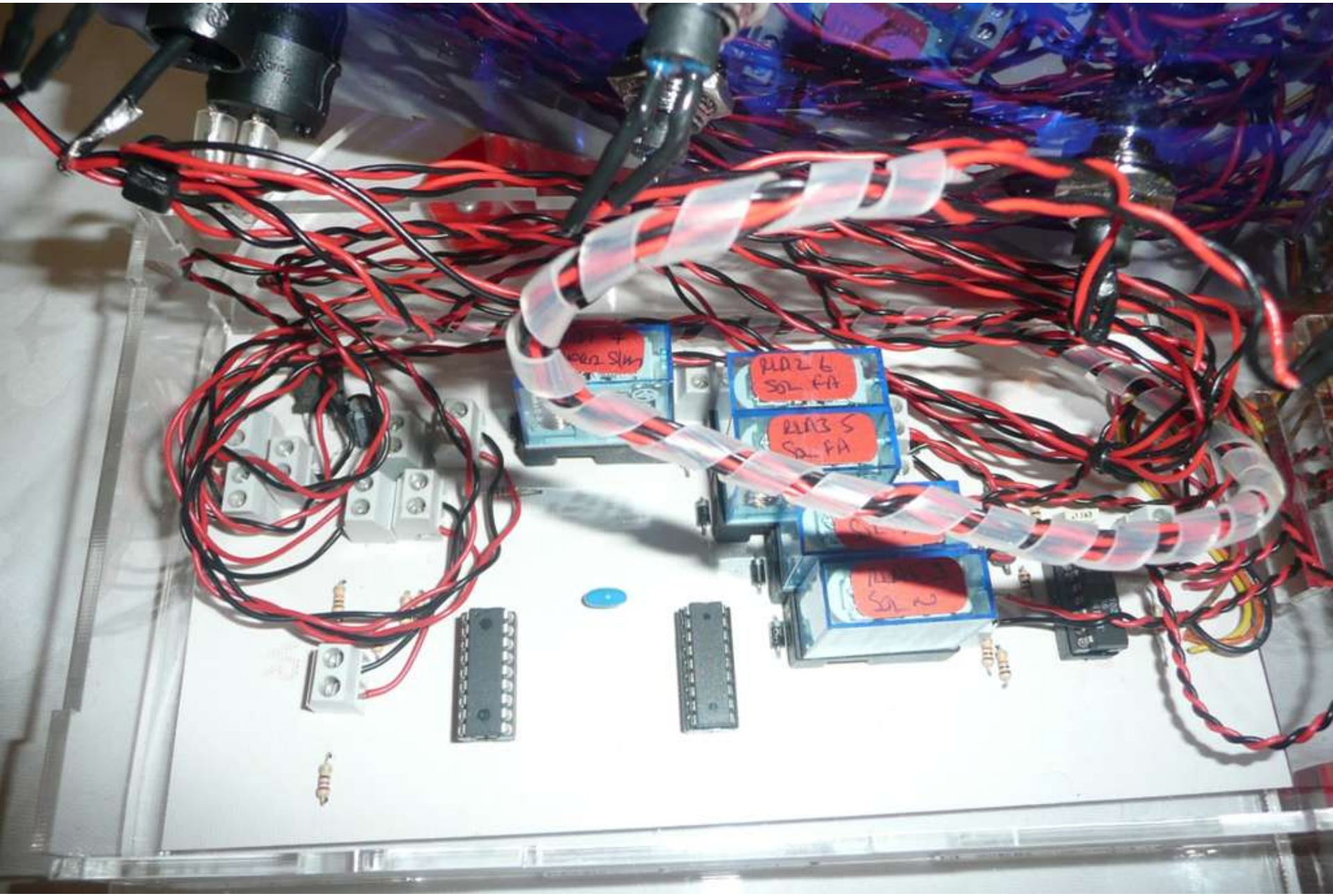





CAUTION
SHARP OBJECTS
GLOVES
REQUIRED
CAUTION
SHARP OBJECTS
GLOVES
REQUIRED
Power LED
Reset
Emergency Stop


Please Keep Hands Away, Thankyou
CAUTION
SHARP OBJECTS
GLOVES
REQUIRED
CAUTION
SHARP OBJECTS
GLOVES
REQUIRED


Year 14
Ryan Bratten
Technology & Design




On/Off
Power LED
Sequence 1
Sequence 2
Reset
Emergency Stop
Cutting Fluid


Candidate Name: R.Bratten
Centre Number: 71337
Candidate No: 8007
Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Problem Identification and Design Brief

Problem Identification

The twist drill bit is the tube produced in largest quantity today. It comprises a cutting point at the tip of a cylindrical shaft with helical flutes. The twist drill bit was invented by Steven A. Morse of East Bridgewater, Massachusetts in 1861. The original method of manufacture was to cut two grooves in opposite sides of a round bar, then to twist the bar (giving the tool its name) to produce the helical flutes. Nowadays, the drill bit is usually made by rotating the bar while moving it past a grinding wheel to cut the flutes in the same manner as cutting helical gears. Twist drill bits range in diameter from 0.002 to 3.5 in and can be as long as 25.5 in. The geometry and sharpening of the cutting edges is crucial to the performance of the bit. Small bits that become blunt are often discarded because sharpening them correctly is difficult and they are inexpensive. For larger bits special grinding jigs are available. A more aggressive (acute) angle is suited for very soft plastics and other materials, it would wear rapidly in hard materials. The bit will generally be self-starting and cut very quickly. A shallower angle, such as 150 degrees, is suited for drilling steels and other tougher materials.

In the Construction industry there is a wide variety of drills and drill bits that are used. This creates the need for high tech drill bits which can drill at any speed depth of angle. This produces a high demand for the drill bits to remain sharp and able to reach their full potential. Because Of this problem systems have been created to keep the drill bits sharp however so far these machines have be hard to use and not very reliable. They also tend to be difficult to use and therefore not be very common around the construction and industry environment. This is a major problem in the construction and industry environment because of the waste of money time and resources used to manufacture, sell and buy new drill bits every time the drill bit becomes worn out and need replacing. These products on the market at the minute are either manual products where by the drill bit must be held in position and the sharpener turned around the drill bit or the other way around, or they are large stationary heavy duty automatic products for rugged use in a harsh environment.

The problem with these devices is that they are either very heavy or stationary or they are light fragile manual products that are easily broke and will not stand up to the harsh industry environments, it would also take a lot effort to effectively sharpen the drill bit flute using a hand held manual operated device. However the stationary devices are very effective at sharpening the flute and restoring it to an almost new condition but these devices create a large amount of environmental disturbance with high noise levels, the electricity used and the leftovers that are discarded.

Drill bits don't necessarily get dull or blunt because of over use or drilling into hard steel or rock or concrete. Drill bits can become dull or blunt very easily drilling into nothing but wood. The reason for drill bits to get dull or blunt is because most of them are just steel and when steel gets hot it melts. The drill bit will not start to melt and fade away however the steel tips of the edges can get hot enough to begin to melt which means that the steel fatigues and the edge is then lost.

On further investigation it was found that most stationary sharpeners are battery powered and have a very small battery life before they need re-charging. However the majority of the devices can be permanently on charge so that they will not run out of battery, however when this happens the overall battery life decreases and when it is finally used without being connected to the main electricity the battery will not hold up for very long at all before it need to be re-connected to the main power supply.

Overall it was found that a wide variety of trades where lacking in a effective drill bit sharpening device that would be able to sharpen the flute back to an almost new state and be power efficient so that the battery life remains high and has a high power output, high enough to effectively sharpen the drill bit.

Design Brief

I am going to design and make a product that will be used to sharpen old worn out drill bits that are in need of re-sharpening so that can be returned to their original state or at least back to an almost new state. The product should be light enough to carry for job to job but strong and powerful enough to sharpen the drill flutes back to an almost new condition and ready to use again this in turn will become more economical as the same drill bit can last you a long time.

Intended Audience

This product is used in the industry environment where there will be a large amount of dust and other power tools that could potentially harm the product if it wasn't produced in such a way that would protect it from this environment. This product is used by builders and other members of the the manual labour trade and is used to sharpen their drill bits once they have been worn down from over use. This product will also be used by hardcore do it yourself' enthusiasts or by self employed trades men who would use their tools a lot and do not have the money to continue to buy new drill bits once they have worn out or even broke.

Function

A drill bit sharpener is a device used to return and old worn out and dull drill bit to its former state by rotating the drill bit on a carbon or diamond tipped grinder until all of the blunt pieces are shaved off and the drill bit is left intact and sharp and back to and almost new state. This product is used for sharpening drill bits sizes 3/32" to 1/2" with 118 angles. It can be used to sharpen titanium cobalt, high speed steel and masonry bits. A Diamond sharpening stone is used for long life and precision sharpening. The product is used to first of all sharpen the tip of the drill bit by rotating either the drill bit or the sharpening tool around the other component thus shaving off blunt material and revealing new sharp material. After this step is finished the sharpener begins on the drill bit flutes which are an essential part of the drill bit.

Diamond incrusted

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Intended environment

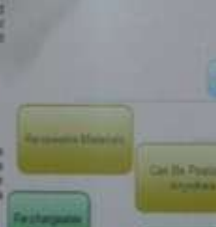
This product will be used in the industry and labour environment to sharpen blunt drill bit on the job. However it can be left stationary in a home workshop which would be used by a hardcore enthusiasts who would be using their drill bits a lot to drill through sheet metal or even wood, this leads up the outer edges of the drill bits and they will then fast and become blunty and it is then that they will need sharpening. If a blunt drill bit it used to drill through a piece of metal it will wear out the drill and the users arm strength as they are having to force the drill bit through the material. It will also put extra strain on the drill and the hole will be cut but it will be left with a ragged edge that will need tidying up creating extra work for the user. The product will be used in a very dusty environment where the pollution from the environment that it is in could potentially damage the product. Because of this the product must be coated in a hard outer shell and must be sealed tightly to ensure that no dust particles can get into the product and corrupt the mechanisms inside. The product could also be used whilst in the back of a van or lorry and could then be prone to getting knocked around or falling off higher benches onto the van or lorry floor whilst moving. Because of this the product must have a very hard outer shell to take the impact of a sudden fall or tumble whilst on the move.

Function 2

The product will be used to re-sharpen old worn out drill bits after they have had a lot of use and to replenish them back to their former state. Drill bits don't necessarily get dull or blunt because of over use or drilling into hard steel or rock or concrete. Drill bits can become dull or blunt very easily drilling into nothing but wood. The reason for drill bits to get dull or blunt is because most of them are just steel and when steel gets hot it melts. The drill bit will not start to melt and fade away however the steel tips of the edges can get hot enough to begin to melt which means that the steel fatigues and the edge is then lost. Whenever this happens the drill bit sharpener will need to be operated to re-sharpener the drill tip and flutes by shaving away blunt pieces and transforming the drill bit back to its original state or at least to an almost new state.

Life in service/time scale

Everyday chores around the house often require special tools for easy repairs. Whatever your task, you want your drill bits to remain sharp and ready for use. Preventive maintenance goes a long way when caring for the bits. A drill bit should be resharpened at the first sign of dullness. The increased load that dullness imposes on the cutting edges may cause a drill bit to break. The challenge is always the same: creating the complicated combination of twisting and rotating motions that the bit must undergo as its tip touches the spinning grindstone. Get this motion wrong, and the drill bit won't drill. Some times when drilling through steel at too high a speed, the bit will overheat, loose it edge and metal can harden a bit. A good drill bit will go through 1/8 steel in a matter of seconds.



Specifications

Material

- This product will be manufactured using many different types of materials. These materials include wood (obeche 30-60mm thickness), Acrylic (sheet 3mm,5mm,8mm and 20mm thickness) and metal (pneumatic cylinders).
- The wood used for the product will be obeche, this is used as it has a number of advantages such as a low bending strength and is easy to carve. Obeche also leaves a creamy white finish that can then be sprayed or treated to provide and aesthetically pleasing finish. It has a low crushing strength and low density and is easily drilled through. These factors lead to it being excellent material to use on my product.
- The product will be mostly created using plastic sheet acrylic which can then be formed or cut into pieces to fit the product. Acrylic is used on this product as it is very strong and resists weathering. It also has more flexibility when compared to class and is less brittle than class. Acrylic is easily cleaned and can be solvent bonded. Acrylic full title is Polymethylmethacrylate.
- The final material used to manufacture will be metal in the form of pneumatic cylinders. These will be used for the main operation of the product. However pneumatic cylinders have moving parts which involves more maintenance and there is also no auto tuning or any complex controls. Manual adjustment must be used for these cylinders and can be more costly to operate as the air has to be compressed and then used to operate the cylinder however they can be cheap simple and very reliable.

Environment

- This product will be used in a workshop or garage of a manufacturing enthusiast, such as someone who restores cars or builds their own products and inventions. This product should be manufactured in a way that allows it to work at a comfortable room temperature of 23°C and also in a cold outside environment of -1 to -2°C.
- The product can also be used on construction sites by builders who would be using their drills constantly and need their tools to be sharp and accurate to avoid rugged and below standard work as this could affect badly on their business or on them.
- The product will be carried around in a van or lorry used by construction workers and may get damaged or knocked around while in transportation.
- Because of these conditions the product has to be manufacture giving special detail to the outer shell of the product so that if the product comes into contact without another appliance whilst in a lorry or van it is protected and is not damaged or disrupted.
- The end bit sharpener will be used in dusty work shops with a lot of clutter, this would disrupt the inner workings of the product. Because of this the product will be manufactured so that dust can not enter the product and disrupt the operation.
- This product will be used in an environment with carrying temperatures from below 0°C and above 15°C this can be stressful to the product mechanisms and circuit board.

Aesthetics

- The physical appearance of products has an effect upon the way in which they are perceived. The aesthetics of the product is therefore used to differentiate from the competition and stimulate consumption, especially when on the market the products are often indistinguishable from each other on a technical basis.
- From the materials used to manufacture the product, it will be produced with a naturally pleasing finish as the acrylic and the metal pneumatic cylinders do not need any further modifications or finishes.
- However the obeche wood does require finishing, this can either be done by staining the wood to give it a natural effect or it can be covered in a veneer.
- For this product the obeche will be spray painted with a colour that will match the rest of the product. This will also protect the product from weathering. Maximum protection for the obeche could be obtained by covering the wood in a veneer however this would be too expensive and would not be economical.
- After the acrylic pieces are manufactured using the Laser cutter and engraving machine they will be polished and cleaned to provide a reflective finish which will catch your eye.
- The product should have no sharp acrylic corners that could shatter or break off if it came into contact with another appliance while in use in its own environment.
- The product be very strong so that it can withstand impact but it will also be aesthetically pleasing to the buyer.

Manufacture

- The main parts of the product will be manufacture using many different types of machinery. Three machines include:

1. CNC Router (used for obeche) (1-2hours)
2. Laser Cutter and engraving machine (used for acrylic) (1-2mins)
3. Vacuum Forming machine (used for Rigid polystyrene moulding) (1-2mins)
4. Strip heater (used for small detailed acrylic pieces) (1-2mins)
5. Milling machine (used for cutter holes and indents on any material) (5-10mins)
6. Stereo lithography (used for creating full finished pieces in one go) (1-2weeks-product must be sent away)
7. Band Facing machine (used to grind away excess material) (1.0mins)
8. Pedestal drill (used for cutting holes into material after they have been manufacture initially by another machine) (1-2mins)

- After all of these machines and edges the product should be ready to be assembled carefully by hand and made into the final working piece after this only small amounts of modification can be carried out on the product without the assembling the product again.
- Small pieces of the product may also be manufactured using files or other hand held tools, these would be used in a case where the piece has been manufactured wrong in the initial machine and excess material has to be files away or changed.

Legal factors

- Products that must meet requirements set out in European Union (EU) directives must carry a CE marking if they are sold in the UK and the rest of the EU.
- Harmonised European Standards provide the simplest way of demonstrating that the product complies.
- Putting the CE marking on the product acts as a declaration that the item meets relevant legal requirements.
- For the product to be sold on any market it must first be inspected or tested by an authorised independent testing body, they will certify it to be sold to any buyer and the product can then obtain the CE marking.
- However seeing as this is a piece of electronic equipment it must pass two other regulations, these are:

1. WEEE (Waste Electrical and Electronic Regulations)
2. RoHS (Restriction of Hazardous Substances Regulations)

- Once the product meets all of these regulations and standards and is correctly labelled it can then be manufacture, distributed and sold anywhere within the EU.

Anthropometrics

- Anthropometric breaks down to: Anthropo-as Human/homework and is the study of human body measurement for the use in anthropology classification and comparison.
- Today anthropometrics plays an important part in [illegible] design, because of this I have had to design my product with this statistic in mind.
- This product will be designed to fit the [illegible] of 189 mm for an adult male, while the average length of an adult female [illegible] 174 mm. The average hand breadth for adult males and females is 84 to 8.74 mm respectively.
- The final product once fully [illegible] so no more than 210x297x210mm (21x29.7x21cm/[illegible]).
- These measurements will allow the product to be easily picked up and carried around so that it can be transported from workplace to workplace in a lorry or van.
- The product will be able to sharpen any blunt drill bit from 0.2 through 0.98 mm this will be very handy and economical for any hardcore enthusiast.

Economics

- Product economics is defined as the study of the cost and cost effectiveness of products for sale.
- These costs include:

1. Labour (Employment of staff or engineers to manufacture the product into make/self manufacture)
2. Material (Cost of buying the materials from hardware stores or suppliers) (£150)
3. Components (Cost of buying new components such as circuit components etc) (£50)
4. Tooling (cost of re-tooling machinery for different operations) (no cost)
5. Investment (cost of investing money and time into the product) (no investment)
6. Purchasing (cost of buying the product after it has hit the market) (no purchasing)

- Altogether these costs can be calculated to produce the final price of the product at market.
- The final selling price can be calculated using the Direct costs + indirect cost + profit = Final Price.
- This calculation should cover all of your expenses and investments while still making a profit.
- Economics can also be viewed into Energy Economics, this involves the use of fuels and energy to manufacture and operate the product.
- This product is to be sold on the market it must pass an emissions test, as this product does not have any emissions what so ever except from clean air it should be able to pass this test easily.
- This product is manufactured out of mainly recyclable materials which can be re-used after the product is finished with or broken.

Size, Shape and dimensions

- The requirements for this product state that it should be kept as small as possible so that it can be easily picked up and transported from workplace to another workplace or environment when needed.
- With this in mind the product should be no bigger than 210x297x210mm (21x29.7x21cm/2.1x2.97x2.1inches).
- This is roughly the same size as an A4 sheet of paper squared. This will keep the product small and not allow it to become to heavy so that it can not be carried or picked up easily.
- If the product is too big it would become useless as it could not be transported and would have to sit stationary and be used from the same position each time, this is impractical and not economical.
- The drill bit sharpener should be in a box shape with one or more corners cut out at a diagonal to create dynamic aesthetically pleasing outer structure to house the rest of the product.
- These structures should allow enough space for the inner workings of the project to be fitted but not big enough so that it is unable to be carried from workplace to another workplace or environment.
- This product should be able to sit on a flat workbox or surface on its own without the need for an extra stand or holder, this means that the product should have a flat base which is either made out of wood (obeche) or out of acrylic (Polymethylmethacrylate).
- The drill bit sharpener will allow all sizes of drill bits to be sharpened back to their original shape and size, therefore the product must allow enough space for the shavings of the drill bits to be collected at the bottom of the product. This mean that a small hole or an to bore the shavings away towards the bottom of the product. There must then be a way of effectively removing the shaving from the product such as a small clip off compartment with the shavings inside or a run off for the shaving the fall out of the product.

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Function

- This product will be used to sharpen blunt drill bits and bring them back to an almost original state. This will be done in six steps:

1. The bit will be opened by hand and the drill bit inserted and the lid is then closed again.
2. Once the lid is closed the power will go through the circuit and the drill sharpener tool connected to the cylinder will go positive and meet the drill bit and start to sharpen.
3. Fluid will then ejected from a small nozzle onto the drill bit to cool it down and help with the sharpening.
4. After the sharpening is over the cylinder will go negative and the fluid will stop being ejected from the nozzle.
5. After all of this small air nozzles will start to dry off any remaining fluid from the drill bit and the surrounding area.
6. The drill bit will then be released from its holder and will drop out the bottom. The lid can now be lifted and the power to the circuit will cut off.

Maintenance

- This product requires very little maintenance once it has been assembled, this is because the pneumatic cylinders used are all self lubricating using the air that is used to operate them. This will keep them running smooth and effectively.
- However with constant use the drill bit sharpener its self may become worn down and need replacing. This is easily done as the old sharpener will snap out of place and the new sharpener click into the empty space left by the old sharpener.
- Once the product has been in use for a while the fluids used to help with cutting and sharpening may need to be replaced due to small amounts of material cut off from the drill bits getting into the fluid reservoir and corrupting the pump used to eject the fluids out of the nozzle. If this happens the reservoir can be easily emptied and the fluids replaced and the product can continue to run safely and efficiently.
- Once the outer casing of the product is finished it should not need any maintenance unless the product is dropped or comes into contact with another appliance and the product is broken, if this happens the outer case will need to be re-manufactured and replaced.

Ergonomics

- Ergonomics is the science of designing user interaction with equipment and workplaces to fit the user and his her needs.
- With this in mind the product should be designed to sit on any level worktop or bench. This will allow the user to work with the product from a comfortable height and not have to bend down or reach up to use the product as this could cause strain to the user.
- This should fulfil our two goals of health and productivity, this way we will be able to get the most from the user and therefore be able to get the most from the product as we can since it has been implicated.

Existing solutions

Size, Shape & dimensions

Aesthetics

Function

Anthropometrics

Maintenance

Material

Size,Shape & dimensions

Aesthetics

Function

Anthropometrics

Maintenance

Material

Size, Shape & dimensions

Aesthetics

Function

Anthropometrics

Maintenance

Material

Size, Shape & dimensions

Aesthetics

Function

Anthropometrics

Maintenance

Material

Design 1

This product is very simple to manufacture as everything is designed and tested first using PRODesktop, which is a 3D modelling software package used to design and test components before they are made.

In these views the lid has been lifted and the mechanism has been brought up which in turn bring the drill bit up in a circular motion away from the sharpener housing. The mechanism was manufactured using 5mm acrylic and in these photos has been rendered in frosted acrylic. 10mm acrylic tubes where used to join all of the pieces of the mechanism together and also allow them to move without fracture whilst the mechanism is being operated.

The housing is moved using the two pneumatic cylinders in either side, these are attached to the housing using an acrylic bracket so that they can run parallel and not directly attached to the housing. These then allow the Housing to run smoothly over the marbles.

Obeche wood was used to create the outer casing inside which this product is housed, this wood was left without any spray paint finish or wood stain, and this is so that the grain and texture of the wood is still visible as this adds to the aesthetic properties of the product.

The tops of these marbles extrude above the flat surface of the box section just enough so that the sharpener housing is sat upon them equally and not on top of the acrylic, this ensures that the housing will move smoothly back and forth as the marbles turn.

1)First of the entire drill bit is gripped by the drill bit holder and is tightened in place securely to ensure it doesn't slip whilst sharpening.

2)The lid of the product is then lowered in, turn operating the mechanism that the drill bit is attached to, this make the drill bit fall into line with the drill bit sharpener.

3) A small amount of fluid is sprayed onto the drill bit whilst sharpening to aid the operation, this is then collected through the sharpener housing by the water pump and re-cycled efficiently off all waster material.

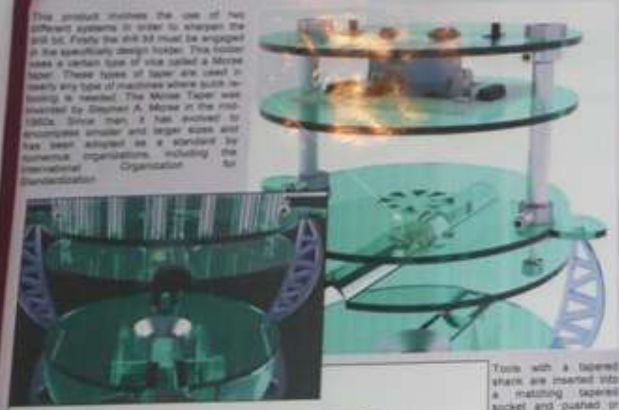
4 Once the sharpener is in position the product begins to operate by turning the power on to the stepper motor which in turn operates the sharpener and this turns around the drill bit taking off all waster material.

5 A small amount of fluid is sprayed onto the drill bit whilst sharpening to aid the operation, this is then collected through the sharpener housing by the water pump and re-cycled efficiently off all waster material.

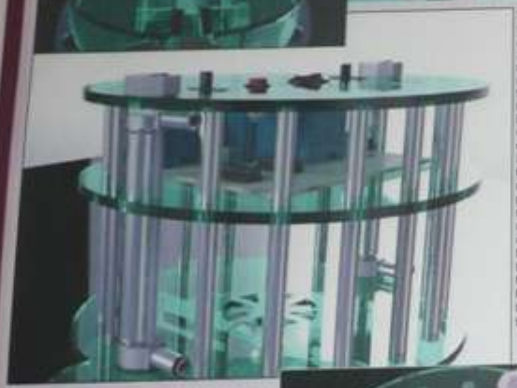
The marble rack allows the sharpener housing to move in a small motion to and from the drill bit which is to be sharpened. The members are 10mm wide and are kept in place by a frosted acrylic box section with 10mm holes cut out for the marble to be set into.

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Design 2

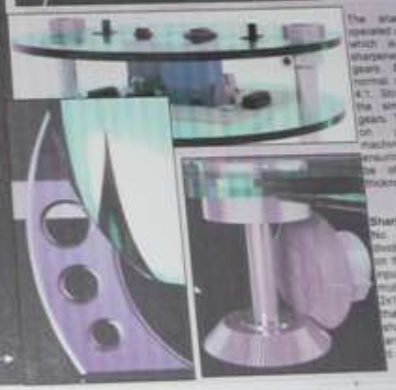


This product involves the use of two different systems in order to sharpen the drill bit. Firstly the drill bit must be engaged in the specifically design holder. This holder uses a certain type of vice called a Morse taper. These types of taper are used in nearly any type of machines where quick re-tooling is needed. The Morse Taper was invented by Stephen A. Morse in the mid-1860s. Since then, it has evolved to encompass smaller and larger sizes and has been adopted as a standard by numerous organizations, including the International Organization for Standardization



Tools with a tapered shank are inserted into a matching tapered socket and pushed or twisted into place. They are then retained by friction. In some cases, the friction fit needs to be made stronger, as with the use of a drawbar, essentially a long bolt that holds the tool into the socket with more force than is possible by other means. Morse Tapers come in eight sizes identified by number between 0 and 7. Often this is abbreviated as MT followed by a digit. Morse tapers can have three types of ends, tang, threaded and flat

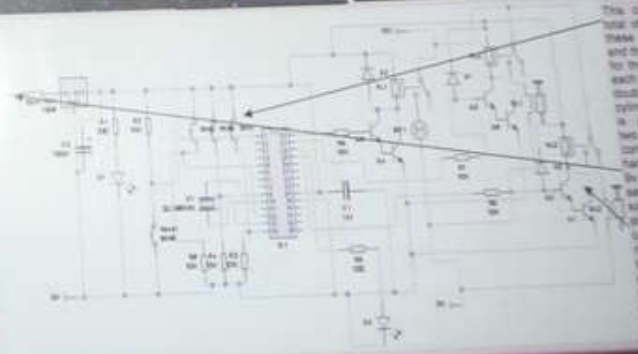
This product stands on its own and is able to be picked up and carried around a workshop or environment. The product is 374mm high and 230mm wide and has a depth of 250mm (37.4cm*23cm*23cm*) However the pneumatic cylinders would make the heavier



The sharpening device is operated using a stepper motor which is connected to the sharpener shaft using 2 bevel gears. Bevel gear have a normal ratio range of 1:1 to 4:1. Straight bevel gears are the simplest type of bevel gears. They are manufactured on precision generating machines by indexing method ensuring that the teeth should be of tapered depth and thickness.

Sharpener speed:
No. of teeth on the driver divided by the number of teeth on the driver multiplied by the input speed= 90/45*2 multiplied by 100rpm= 2x100=200rpm. This means that once engaged the sharpener will spin at 200rpm around the drill bit and sharpen it in seconds

This product has a thick green acrylic base and inside this main is where the second acrylic product is covered by a grey the whole product four identical blue a are design to follow the of the product whilst providing the strength and stability to hold the product in an upright position. On the left is an image of the control panel used to operate the product. The buttons are very simple, one of the power to be turned on to the rest of the circuit. One for the stepper motor at the base f the product to be turned on and start the rotating of the sharpener. One for the pneumatic cylinders to go up and down to allow the drill bit to reach the sharpening device and start the sharpening process and the last on is an emergency reset switch encase something goes wrong

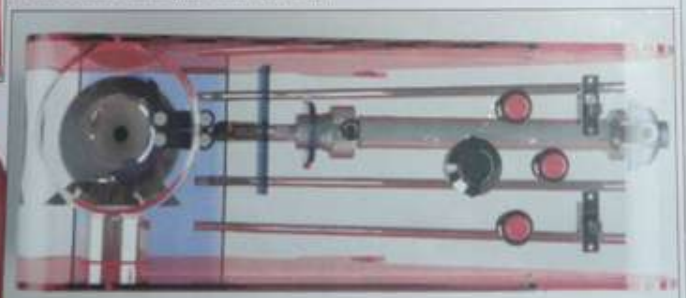


This circuit has a total of six outputs, these include a led and the four outputs for the two ports of each of the two double acting cylinder. This circuit is powered using two power sources coming from the left hand side and the 9v rail (top left). The second power source only run the stepper motor output so that it is not constantly on as it would become to warm and eventually burn out, causing the stepper motor to be changed

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Design 3

This product is operated using only one pneumatic cylinder, this allows the product to be a lot more compact and not as heavy than other products on the same market. The product is encaged by 3mm acrylic sheets which have been shaped to suit the low pit of the product. At the back of the product there is four solid polished steel bars to allow air to flow through the product so that it does not overheat when in use as this may cause it to burn out of catch fire.

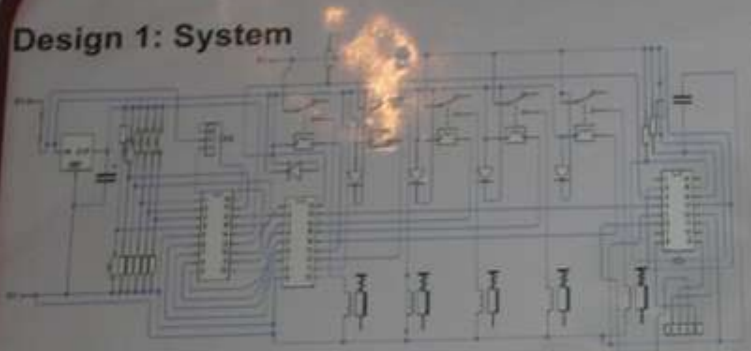


One of the key design features of this product are the claws in which the drill bit is held. These claws are operated by a double acting cylinder, the cylinder pushes the up wards in between the two sets of claws which have a permanent pivot point so that when this happens the back of the claws will go outwards and the front of the claws will go inwards and take hold of the drill bit

Ryan Bratten
A2 Technology
Drill Bit
Sharpener

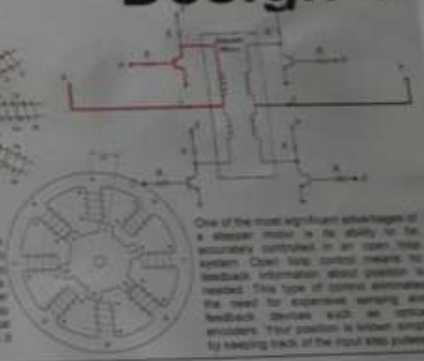
Design 4

Design 1: System



This product is operated using buttons on the top surface of the case. These buttons are wired into a breadboard shown here on the left. The circuit board has two inputs of 9v, one to power the main circuit and another to power the stepper motor so that it is not constantly rotating as this will cause it to burn out. The circuit has three chips which process all of the inputs from the buttons and the power. The outputs of this circuit are connecting into the circuit through other components. These outputs include two pneumatic cylinders and a stepper motor as mentioned above.

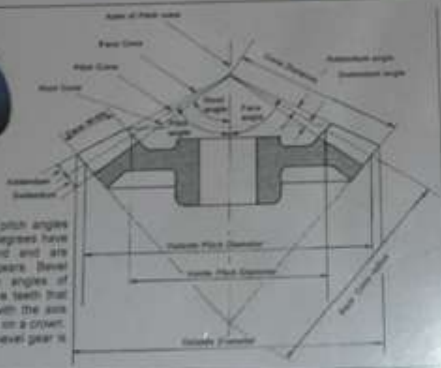
A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence.



One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping track of the input step pulses.

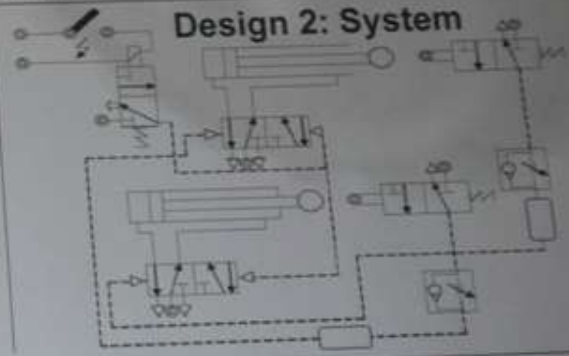
Sharpener speed:
No. of teeth on the driver divided by the number of teeth on the driver multiplied by the input speed= 9043r/2 multiplied by 130rpm= 2x130r/200rpm. This means that once engaged the sharpener will spin at 200rpm around the drill bit and sharpen it in seconds

Bevel gears that have pitch angles of greater than ninety degrees have teeth that point inward and are called internal bevel gears. Bevel gears that have pitch angles of exactly 90 degrees have teeth that point outward parallel with the axis and resemble the points on a crown. That's why this type of bevel gear is called a crown gear.



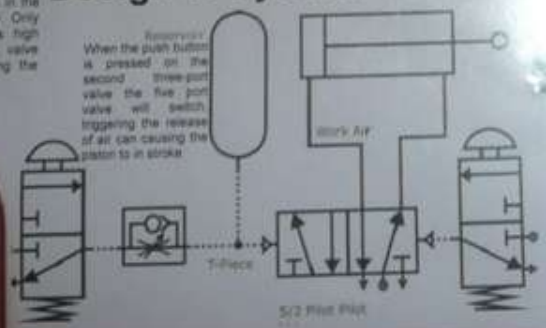
This product is operated using a time delay sequential control pneumatic system using a combination of flow regulators and reservoir with a double acting cylinder. The sequence is started by pressing and releasing a solenoid operated 3 port valve this send the air signal to the 14 of side of both cylinders at the same time. Once both cylinders have gone positive they will operate the plunger operated 3 port valve. This in turn will send the air signal through a time delay involving a flow regulator and a reservoir on its way to the 12 side of both cylinders. This will send them negative and the sequence has come around full circle and is back to its original position. The initial 3 port valve can then be operated again and the sequence will re-start.

Design 2: System



When the push button on the three port valve on the left is pressed the air flow is restricted by the unidirectional-flow control valve and slowly enters the reservoir. The pressure builds in the reservoir slowly causing the time delay. Only when the pressure in the reservoir is high enough will it operate the five point valve triggering the release of air and causing the piston to outstroke

Design 3: System



These are views of the claw for my third design. This claw is operated using a single double acting cylinder. The cylinder pushes up through the inside of the two sets of claws and pushes the outside of them away from each other and the tops of the claws into towards the drill bit that it will be holder and the process is over

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Inspection of Ideas for Further Development

Size, Shape and dimensions

When designing this product I was given a total workable area to use and design upon of 600mm*290mm as this was the maximum cut-able size in relation to the laser cuttings machines available. This product was intentionally designed to be a lot smaller than these measurements, this resulted in the final product including the outer casing being 420mm*290mm*297mm (42cm*29*29.7cm) However this will allowed the product to be a considerable size and if manufactured may have been to big to carry around and may not have been as portable as other products on the market. 1/5

Aesthetics

This product has been encased by a solid obeche outer shell there is a lot of extra space onto which more detail could have been added to further enhance the aesthetics of the product. The obeche wood was left unfinished so that the grain and texture and natural finish could be left on view. The rest of the components excluding the pneumatic cylinders have been designed using coloured acrylic. This creates a reflective and very pleasing finish to the product. The majority of the product was designed using either 3mm or 5mm acrylic (0.3cm or 0.5cm). The lid of this product Acts as the operator for the mechanism as it is connected to this. As a result of the natural finish on the obeche wood the product is not as well presented as others on the market. 2/5

Function

First the entire drill bit is gripped by the drill bit holder and is tightened in place securely to ensure it doesn't slip whilst sharpening, the lid of the product is then lowered in turn operating the mechanism that the drill bit is attached to, this make the drill bit fall into line with the drill bit sharpener. Then a small amount of fluid is sprayed onto the drill bit whilst sharpening to aid the operation, this is then collected through the sharpener housing by the water pump and re-cycled efficiently getting rid of all waste material. Once the sharpener is in position the product begins to operate by turning the power on to the stepper motor which in turn operates the sharpener and this turns around the drill bit taking off all waster material. A small amount of fluid is sprayed onto the drill bit whilst sharpening to aid the operation, this is then collected through the sharpener housing by the water pump and re-cycled efficiently off all waster material. 4/5

Ergonomics

This design is one of the more complicated designs to operate and manufacture as the mechanism must align perfectly with the drill bit sharpener or else the drill bit will be cut at a wrong angle and this will cause major damage to the drill bit. This design is the least user friendly device out of the three designs, the buttons are on the top of the product but the drill bit must be inserted in just the right place and the pneumatic cylinders moved to fit around the drill bit, if this is not carried out correctly the drill bit will be offline and fall out of its holder whilst being sharpened or it will be sharpened at an angle which will cause major damage to the material that it is next used on. This product is also the largest out of the three designs and therefore is not as portable as the other designs. 2/5

Maintenance

This product requires the most maintenance of the three designs as the cylinders and drill bit must be kept well lubricated during the sharpening phase. This requires a water pump to be designed into the product to circulate the water around the product and onto the drill bit again, this is to keeps the drill bit cool and to stop it from warping whilst being sharpened. The need for the drill bit to be lubricated requires a water collector to be designed underneath the drill bit so that the excess fluid can be collected and then re-circulated. 3/5

Material

This product uses three different types of readily available materials. These materials are Obeche wood, sheet acrylic plastic and aluminium in the pneumatic cylinders. The obeche is used to encase the product in a solid but yet light material. The acrylic plates are used to hold components in place and also used for the main mechanism that will position the drill bit. 4/5

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Size, Shape and dimensions

When designing this product I was given a total workable area to use and design upon of 600mm*290mm as this was the maximum cut-able size in relation to the laser cuttings machines available. This product was intentionally designed to be a lot smaller than these measurements, this resulted in the final product including the outer casing being 37.7mm*260mm*265* (37.7cm*26.5cm*26.5cm) This product was designed to be this size as it needs to be capable of being carried around a workshop or home garage. These dimensions allow the product to stay inside the maximum size and also be big enough to hold all sizes of drill bits. 4/5

Aesthetics

This product has no outer shell or case as the whole product is structured around the two pneumatic cylinders which are held in place by two 3mm acrylic circles and these are held together and strengthened by steel rods running in-between the two circles the rest of the product is connected using 5mm acrylic pieces. Green and blue coloured acrylic was used in this design to show off different features of the product. This creates a reflective and very pleasing finish to the product. The majority of the product was designed using either 3mm or 5mm acrylic (0.3cm or 0.5cm). The bottom of the product is hollowed out and is used to hold the main component of this design, the motor and the sharpening mechanism including the two bevel gears used to transmit motion three 90 degrees. These components are visible through the acrylic as it is translucent. 4/5

Function

First of all the drill bit must be inserted into the holder which is in the middle an acrylic circle. To do this the pneumatic cylinders must have gone negative or else you will not be able to fit in the drill bit in. The holder must then be clamped shut to hold the drill bit in place and it must be checked that the sharpener and drill bit are aligned correctly, if this is not checked the drill bit may fall out of its holder or it may be sharpened at an incorrect angle which can seriously damage the material onto which it is next used. The next step is too lower the product onto the sharpener using the buttons on the operation panel which is placed on the very top of the product so that it is easier to use. After this step is completed the motor can be turned on which will make the two bevel gears spin and transmit rotary motion through 90 degrees to the sharpener rod which is attached to the sharpener. After the drill bit is sharpened, all of these steps are completed again but in reverse and the operation is finished. 4/5

Ergonomics

This design isn't very hard for the user to operate if the steps above are carried out exactly however if they are not the drill bit may be aligned incorrectly and not secured into the holder properly. This may seriously damage the drill bit or may damage the product if the heavy drill bit where to drop onto the acrylic surface below. This design is one of the more user friendly designs out of the three as the buttons are easily accessed and there are not as many wires to go through to operate the device however the only disadvantage to this product is that there is no outer casing so the user may be able to hurt him or herself on the spinning sharpener if they accidentally put there hands into the product while it was in operation. 3/5

Maintenance

This product requires very little maintenance other than to check that the sharpening device has not become worn out over time and replace it if it has and also to check if the drill bit I aligned correctly. To keep the product as small as possible no fluid system was included in the product this makes the product a lot lighter as well. However because there is no fluid system the drill bit can not be cooled while in operation and this may lead to the drill bit overheating, if the drill bit overheats then warping could occur. If warping of the drill bit occurs then the drill bit is now useless as it is no longer straight and the hole which would be drilled with this bit would not be straight either. 3/5

Materials

This product only uses two types of materials. However both of these materials are readily available and easy to use. These materials are acrylic plastic in the form of a sheet and also aluminium in the form of the pneumatic cylinders and also in the supporting rods which hold together The top and bottoms Circles and the Pneumatic cylinders 3/5

Size, Shape and dimensions

When designing this product I was given a total workable area to use and design upon of 600mm*290mm as this was the maximum cut-able size in relation to the laser cuttings machines available. This product was intentionally designed to be a lot smaller than these measurements, this resulted in the final product including the outer casing being 284.7mm*175.5mm*95.5 (28.47cm*17.55cm*9.55cm) This product was designed to be this size as it needs to be capable of being carried around a workshop or home garage. These dimensions allow the product to stay inside the maximum size and also be big enough to hold all sizes of drill bits. This is also the smallest and lightest of the three designs making it the most portable design by far. 5/5

Aesthetics

This product is the most aesthetically pleasing design out of all three. In this design I made use of the different colours of acrylic plastic available to me and how they could be shaped a used to create my claw mechanism which holds the drill bit whilst it is being sharpened. The majority of the design uses red tinted acrylic however blue tinted acrylic is also used to highlight certain key areas of the product. This creates a reflective and very pleasing finish to the product. The majority of the product was designed using either 3mm or 5mm acrylic (0.3cm or 0.5cm). As the back of the product four aluminium tubes are used to help support the product as that it doesn't twist or break whilst sharpening and stays rigid and strong as it should. These tubes also allow air to pass through the product to help keep the drill bit as cool as possible as there is no fluid system in this design. 5/5

Function

First the product must be connected to its power supply and then the special claw mechanism must be operated to hold the drill bit correctly. If this step is not carried out correctly the drill bit may fall out of the claw and damage its self or the product around it, the drill bit may as be aligned wrong and this may cause the drill bit to be sharpened at an incorrect angle. If this happens the material onto which it is next used will also be damaged and a perfect hole will not be drilled. The drill bit must then be checked that it is at the right height to be sharpened and that is reaches the drill bit sharpener at the bottom of the product. After this step is completed the motor can be turned on which will make the two bevel gears spin and transmit rotary motion through 90 degrees to the sharpener rod which is attached to the sharpener. After the drill bit is sharpened, all of these steps are completed again but in reverse and the operation is finished and the new sharp drill bit can be removed from the product. 4/5

Ergonomics

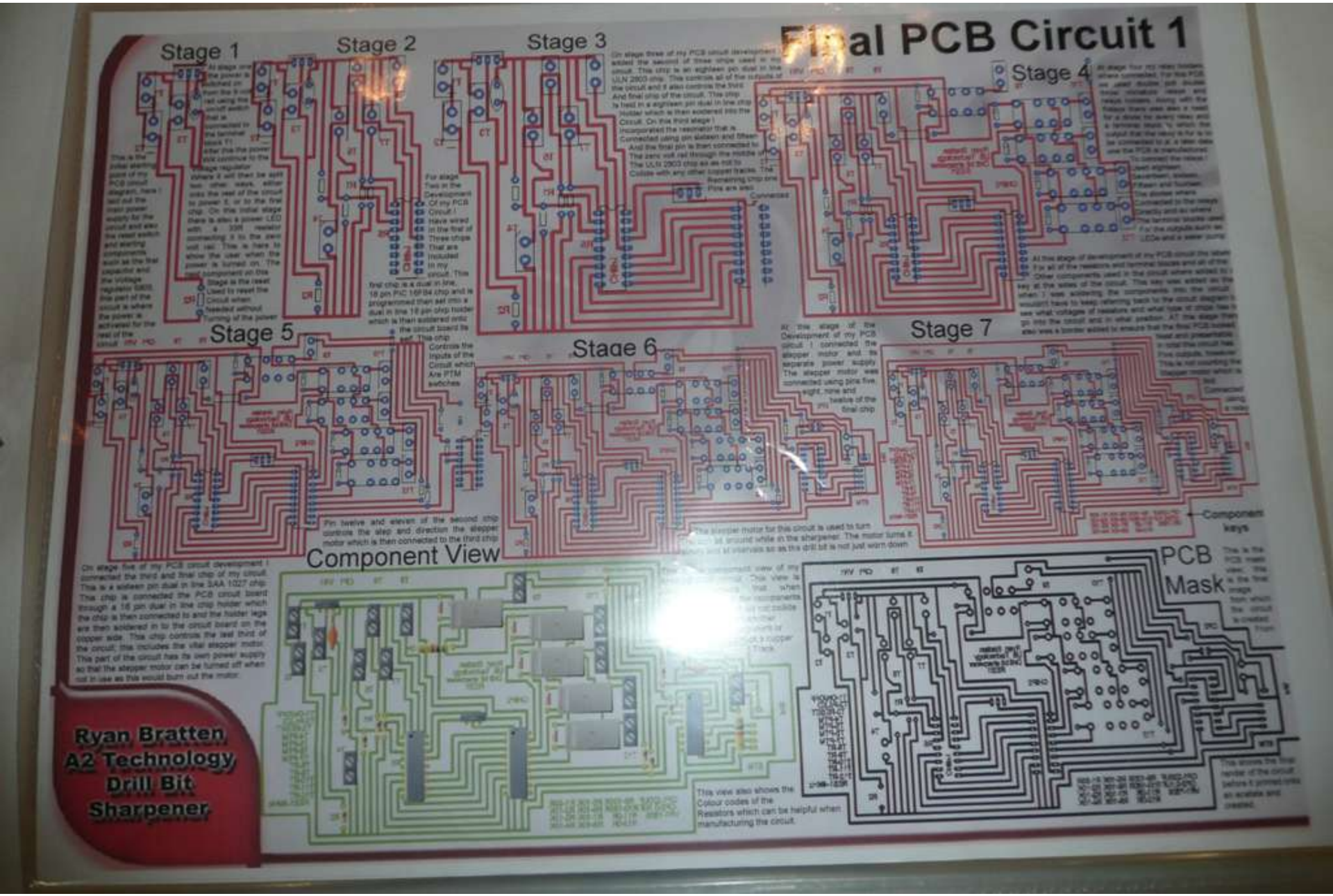
This is the easiest design out of the three to operate because as long as the drill bit is in the correct position and aligned correctly then nothing else can go wrong as the product has enough of an outer casing for the user not to be able to get his or her hands into the product and damage them on the drill bit sharpener. 2/5

Maintenance

This product requires very little maintained other than to check that the sharpening device has not become worn out over time and replace it if it has and also to check if the drill bit I aligned correctly. To keep the product as small as possible no fluid system was included in this product this makes the product a lot lighter as well. However because there is no fluid system the drill bit can not be cooled while in operation and this may lead to the drill bit overheating. If the drill bit overheats then warping could occur. If warping of the drill bit occurs then the drill bit is now useless as it is no longer straight and the hole which would be drilled with this bit would not be straight either. 4/5

Materials

This product only uses two types of materials. However both of these materials are readily available and easy to use. These materials are acrylic plastic in the form of a sheet and also aluminium in the form of the pneumatic cylinders and also in the supporting rods in the very back of the product which help to structure and support the entire product. 3/5


Final PCB Circuit 1
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Component View
PCB Mask
Component keys
Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Final PCB Circuit 2

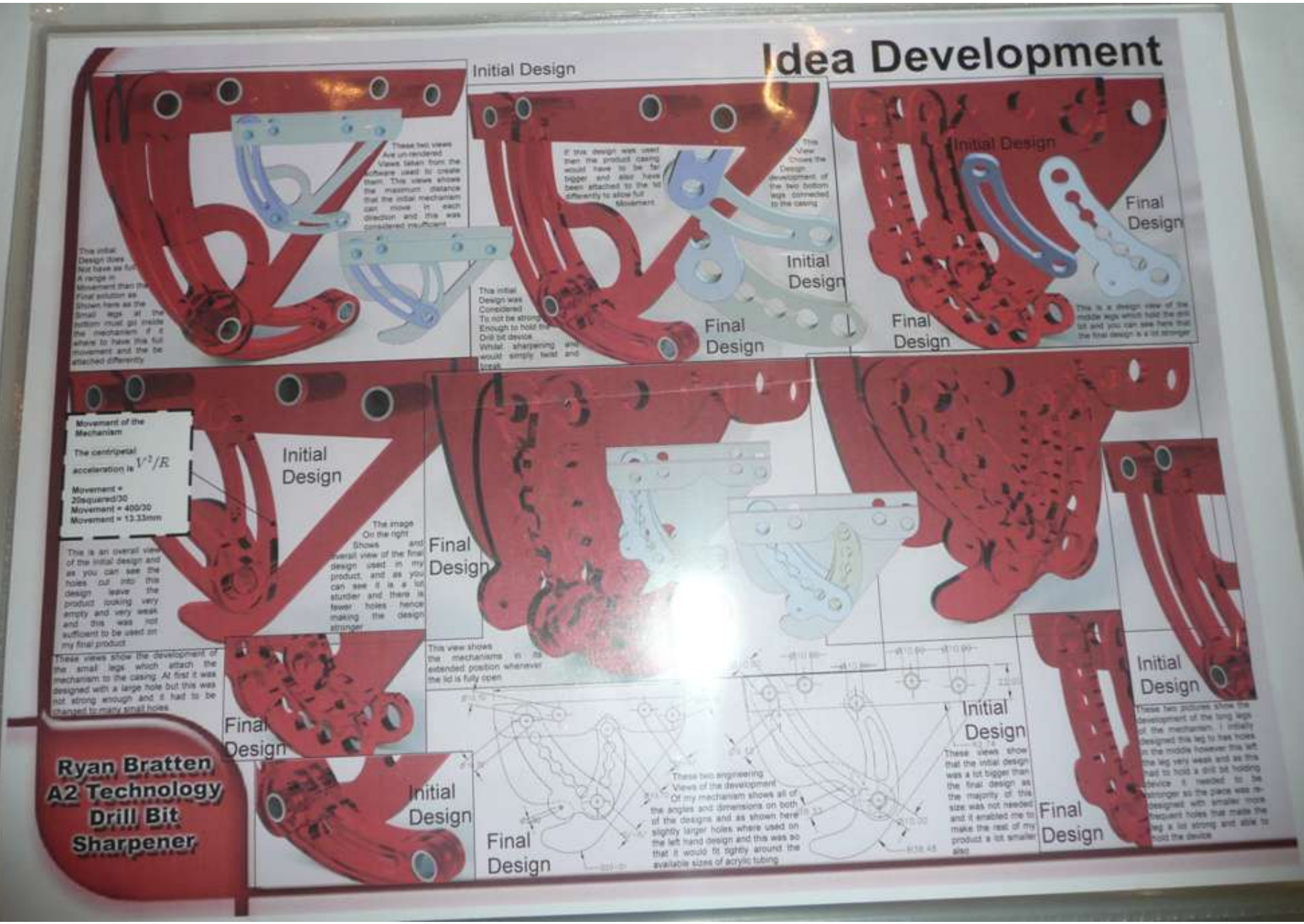
Livewire Circuit

Livewire to PCB

PCB Mask

Component Side

Ryan Bratten
A2 Technology
Drill Bit
Sharpener


Idea Development
Initial Design
Final Design
Initial Design
Final Design
Initial Design
Final Design
Initial Design
Final Design
Initial Design
Final Design
Initial Design
Final Design
Movement of the Mechanism
The centripetal acceleration is V^2/R
Movement = 20squared/30
Movement = 400/30
Movement = 13.33mm
Ryan Bratten
A2 Technology
Drill Bit
Sharpener


Idea Development 2
Initial Design
This view on the left shows the initial design of the circuit holder. This holder is attached into the base of the product however it was not strong enough or aesthetically pleasing
Final Design
These two views are of the final design of my stepper motor holder, this holder is very aesthetically pleasing and is manufactured out one one solid piece of 3mm acrylic. This piece of acrylic was then folded into shape using the line bender. This component can be screwed into the water reservoir so that the stepper motor will not move whilst sharpening. The stepper motor in this design is screwed straight onto the piece of acrylic so that it is held securly and can not move about whilst the sharpener is rotating around the drill bit.
Final Design
Final Design
These two views are of the final design for my holder but in two different colour combinations or acrylic.
Final Design
Initial Design
This exploded and expanded view shows the initial design of my stepper motor holder. This holder was designed with a jigsaw in mind however this didn't not create a strong enough holder for the stepper motor and simply broke whilst it was in use and sharpening
Stepper motor torque calculation
T1 = torque of the first wheel
H = holding torque
θ = step angle, in radians
θ = shaft angle, in radians
These are the views of the development of the pneumatic cylinder holders which go over both ends of the cylinders to secure them
Initial Design
This design was Created using six Pieces of acrylic Clued together Using liquid solvent To hold all of the Jigsaw pieces Together. However this design was considered to not be strong enough to hold the product together despite the whole component being screwed to the water reservoir
Initial Design
Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Idea Development 3

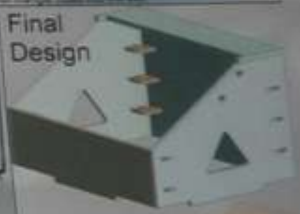
Initial Design

This is the initial design for the casing of my product. This design was held together using liquid solvent however this was considered not strong enough and had to be redesigned, the mechanism here is positioned on the right hand side on the red piece of acrylic and has to be moved up and down separately from the main lid

This is a plan view of the initial design. This view shows the main lid with the slot cut out for the mechanism. However this large lid was considered un-necessary and was re-designed into my final design

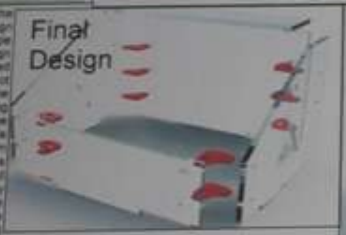
Final
Design

These acrylic triangles were created by cutting the yellow piece out first with the shape of an exploration mark in the middle, the exploration mark was then cut out in black and glued into place using liquid solvent. A hole was then put into the side of the casing and the first triangle glued into this slot



Initial Design

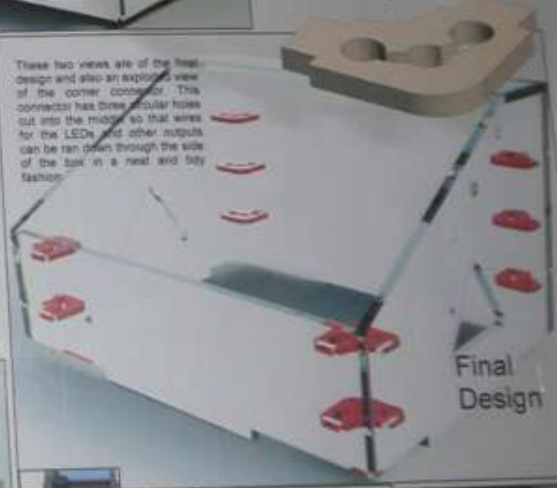
These views are of the sides of my final design and show the triangle warning sign design that I have incorporated all around my product to alert the user to the hazard of the moving parts inside the product. This side is made out of 6mm acrylic sheet and is totally transparent and extremely aesthetically pleasing. Slots have been cut out of the side of this design so that the corner pieces that hold the product together can slot into place. These are then glued in and secured using liquid solvent to hold the box together



This is an exploded and expanded view of the final design and this shows the corner connectors in detail and also the thickness of the material

This view shows the full case put together with all of the corners in place. A lid is then added to this so that the mechanism that goes on the right hand side can move up and down. This case is very aesthetically pleasing to the eye and a lot stronger than my other design

These two views are of the final design and also an exploded view of the corner connector. This connector has three circular holes cut into the middle so that wires for the LEDs and other outputs can be ran down through the side of the box in a neat and tidy fashion



F = pA = p π d²/4

F = 35*3,14*10squared/4 = 109.9*10squared/2 = 10990/2 = Force = 5495nm

This view shows where the circuit is held in this product. This is on the left hand side at the bottom below the red piece of acrylic. This allowed the circuit to be close to the rest of the components

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Final Design

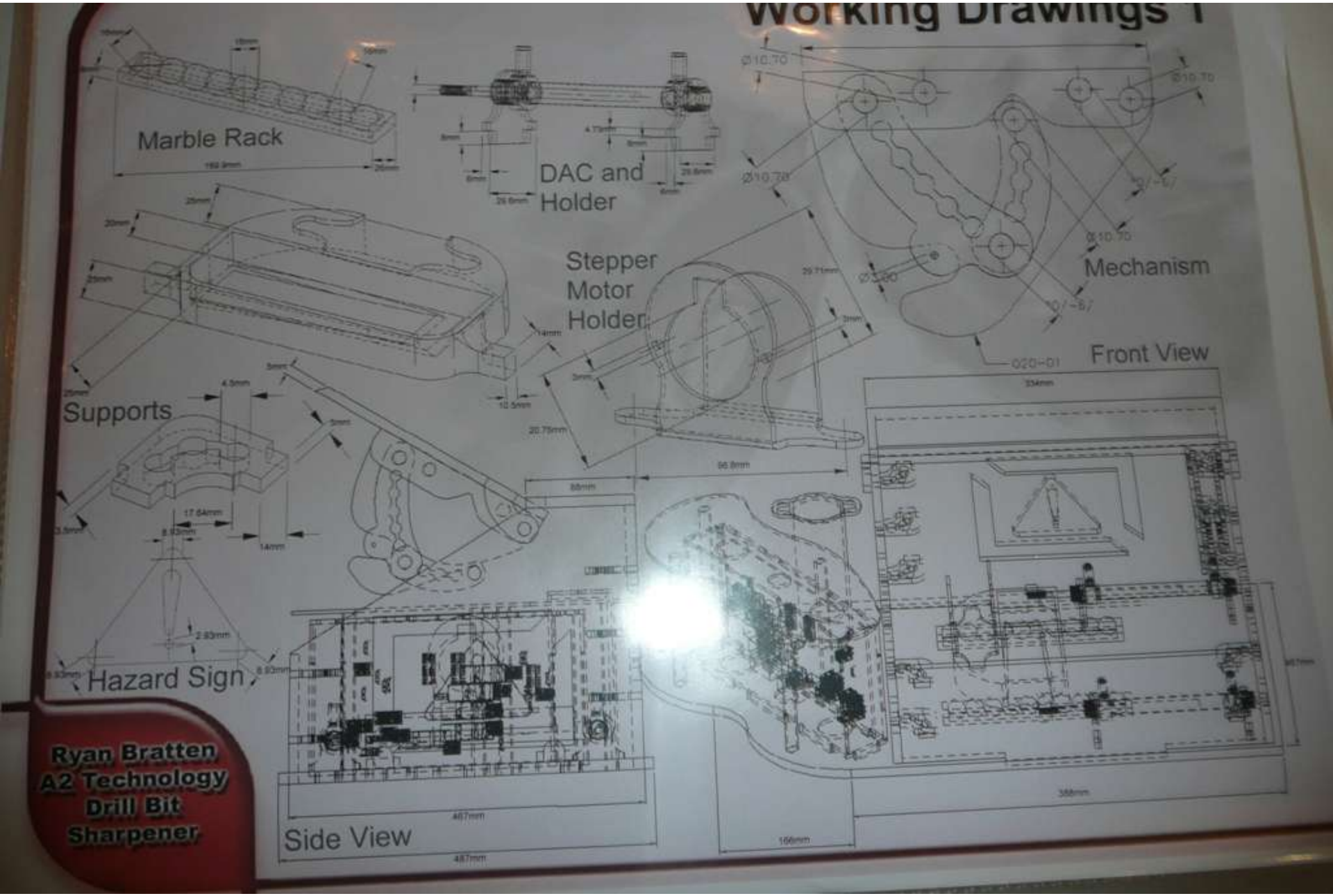
This view shows the whole product in its entirety completely assembled. This view shows the outer case which is made of 5mm sheet acrylic and cut in a laser cutting machine as with all of the other acrylic pieces including the lid mechanism to make the drill bit come away from the sharpener and out of the box where it can then be dismounted from its holder

The machine are then incase in a piece of 5mm red acrylic box to keep them from moving away from the product. The two pneumatic cylinders are held in place by 8 brackets, 4 per pneumatic cylinder and 2 per side. These screw onto the end of the cylinders and fasten tightly

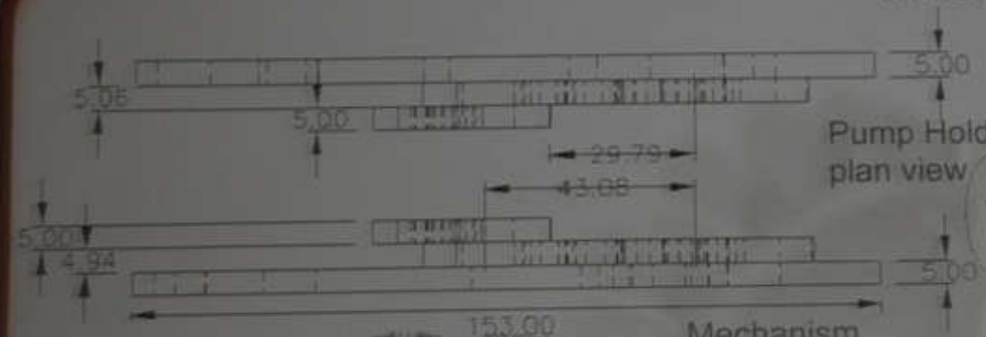
This is a section view of the main acrylic [illegible] final design. This is a combination of the [illegible] has here been mounted in an [illegible] then screwed into the [illegible] is situated upon bot 18mm [illegible] the collector t move freely towards and [illegible] bit

A hole is drilled in the purpose built lugs on the outside of the water collector and the ends of the piston rods are then attached to these. Once all of these ends have been completed the section with move freely towards and away from the drill bit

Ryan Bratten
A2 Technology
Drill Bit
Sharpener


Working Drawings 1
Marble Rack
DAC and Holder
Mechanism
Stepper Motor Holder
Supports
Front View
Hazard Sign
Side View
Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Working Drawings 2

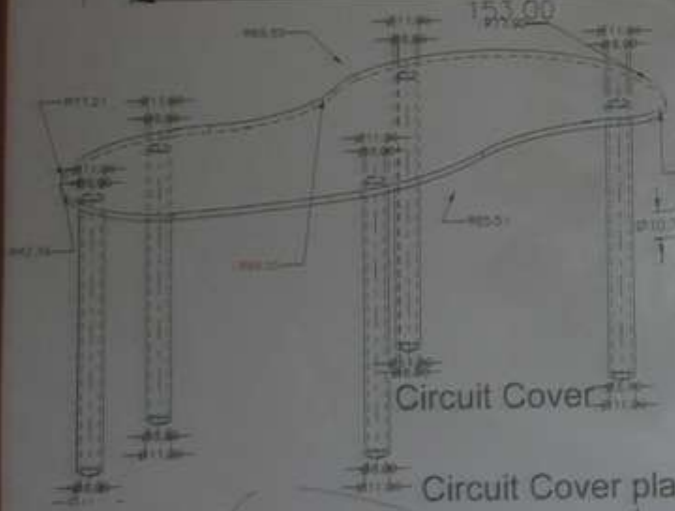


Pump Holder plan view

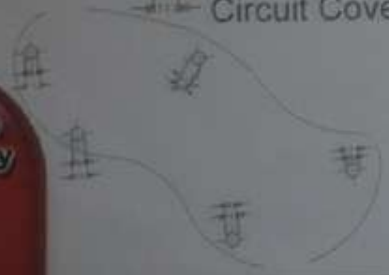
Mechanism

Mechanism 3D

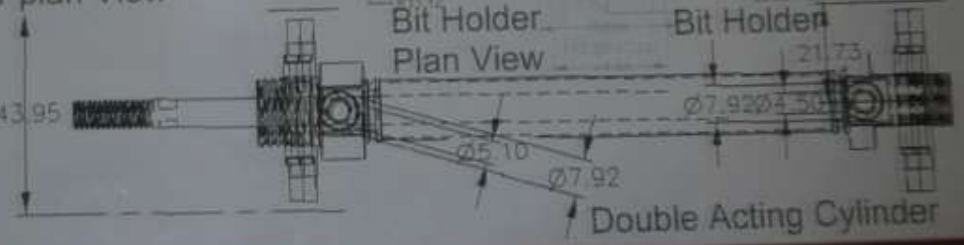
Pump Holder



Circuit Cover



Circuit Cover plan View



Bit Holder Plan View

Bit Holder

Double Acting Cylinder

Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Plan of Manufacture

Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Component Code	Start Date	Completion Date
Casing	09/01/10	10/18/10
C1	09/01/10	09/14/10
C2	09/14/10	09/28/10
C3	09/28/10	09/27/10
C4	09/27/10	10/01/10
C5	09/28/10	10/09/10
C6	10/01/10	10/18/10
Circuit	09/28/10	11/02/10
C1	09/30/10	10/05/10
C2	10/06/10	10/14/10
C3	10/14/10	10/22/10
C4	10/22/10	10/31/10
C5	10/28/10	11/09/10
Water Pump	10/08/10	11/10/10
W1	10/28/10	11/04/10
W2	11/04/10	11/15/10
Mechanism	11/16/10	01/01/11
M1	11/16/10	11/17/10
M2	11/18/10	11/29/10
M3	11/16/10	12/23/10
M4	12/23/10	12/31/10
M5	12/30/10	12/31/10
M6	12/30/10	01/01/11
Sharpener	12/03/10	01/22/11
S1	12/03/10	12/16/10
S2	12/16/10	12/24/10
S3	12/25/10	01/01/11
S4	01/01/11	01/05/11
S5	01/04/11	01/11/11
S6	01/11/11	01/16/11
S7	01/07/11	01/22/11
Other Components	01/25/11	04/01/11
O1	01/26/11	01/30/11
O2	01/29/11	02/03/11
O3	02/03/11	02/14/11
O4	02/10/11	02/16/11
O5	02/21/11	02/26/11
O6	02/26/11	03/11/11
O7	03/06/11	03/17/11
O8	03/17/11	03/22/11
O9	02/26/11	03/23/11
O10	03/23/11	03/26/11
O11	03/24/11	03/31/11
O12	03/17/11	04/01/11

Modifications during Manufacture

Initially the side of this product was made whole with only a small triangle cut out to allow the yellow and black insert to be glued in. However when it came to mounting the cooling fluid there was no area for the pipe to get to the slot so a pipe hole had to be drill in the side of the outer casing, and directly above the stepper motor and then this hole was widened to allow the pipe to move in and out, backwards and forwards as the stepper motor moved.

As this piece was created in the CNC Micro-router I was not able to design and manufacture a hook into these jaws. This was because the end bit can only cut from the top down and then the final piece has to be cut from the surrounding wood and waste material using the ban saw. After this the two holes in each arm had to be cut in the weakest grit and clamped into place to ensure that the wood would not split in place as then the whole piece would have to be re-designed and re-made taking up valuable materials and time that could be spent manufacturing.

When the piece was initially the work for the cylinders to be mounted where designed and made in the wrong position and rather than make the whole piece again this slot piece was created to be fixed onto the top of the motor holder. Fortunately this piece again should have been a big waste of materials and time which could have been spent manufacturing the product.

Initially the wooden block was made only 10mm wide and the slot to be used on the final product however when drilling and tapping the hole in the top the pieces cracked and broke, not all but enough not to be useful so to save the extra hour of gluing and adding on the part, it be widened to 14mm and the hole to be drilled.

When we came to mount the cylinders onto the stepper motor holder initially the holes where to be tapped and screwed in so that they would be easily removed later on in the process however these had to be closed as the wood was to soft.

MODIFICATION 1: PIPE HOLE
This hole was not initially needed and was left out of the design when it was been cut

MODIFICATION 2: DEATAIL PLATES
These plates where needed to cover over a damaged section of the acrylic lid

MODIFICATION 3: COLLECTOR HOLE
Initially the cylinder piston rods where to be fixed on however later a hole had to be drilled.

MODIFICATION 4: BIT HOLDER
Initially the acrylic piece was designed to be 10mm in thickness however when it came to drilling and tapping the hole for the threaded bar the piece simply twisted and broke the lead to the piece being re-designed and as new 5mm in thickness and did not break

MODIFICATION 5: RED PLATE
Initially the cylinders where to be fixed directly into the base of the product however when everything was manufactured it became clear these were not in the correct place as this plate had to be designed and put over the top with the suits in the right place

MODIFICATION 6: AIR INLET
When designing the product a small hole for the air inlet pipe from the compressor was forgotten about and was not created in the lower collar. This lead to a problem when the product was finished as a small hole had to be drilled on the top right hand side of the pipe

When the outside case was created again there was no hole designed into the side as a small pilot hole had to be drilled and then made bigger to allow the small pneumatic tubes to come out of the product and into the main air outlet and air pressure compulsed

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Evaluation Against The Specifications

Material

Manufacture

Economics

Environment

Legal factors

Size, Shape and dimensions

Aesthetics

Anthropometrics

Function

Maintenance

Ergonomics

Ryan Bratten
A2 Technology
Drill Bit
Sharpener

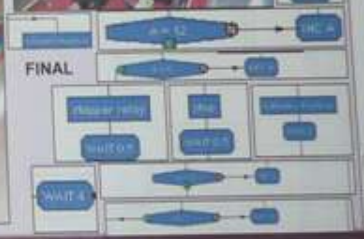
Testing

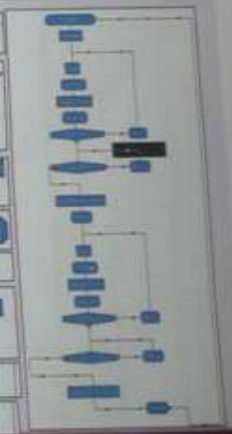
Once my product was finally finished, everything except from the circuit box cover was glued or secured in place. The circuit board cover was left unglued so that the whole system could be tested and any problems or error diagnosed and then fixed again so that the product was full working order.

A sequence using the PIC programmer was then created. This allowed the product to operate fully. Firstly the lid would be lower and the stepper motor sharpening blade would rotate and move into contact with the drill bit causing fluid would then be sprayed onto the drill bit and then stop again and the sharpening tool would move away.

When I was testing initially the PIC chip had to be programmed correctly and we found the our solenoids where polarised and would burn out if an extra diode wasn't added to the terminal block of each relay. After this was completed the circuit was in full working order and all first the water pump was tested using the two, blue power packs shown in the images. The water pump was connected to one of these two power outlets and the pump was tested to ensure that water or cooling fluid would be able to pump through it and onto the drill bit at a later date. Once this had been established that I was in full working order we moved onto the next stage of the product testing process.

After the water pump was in full working order the mechanism was tested to ensure that it was in full working order and that when the lid was lowered the drill bit would be in perfect alignment with the centre of the stepper motor sharpening component. If this was not perfectly aligned then the product would break when the drill came into contact with the sharpening unit. Once the alignment was checked and ensured that it was correct the next stage of testing began.





Once these initial testing processes where over and everything was working attention then turned to making sure that the product operated in the way that it should using the pneumatic cylinders and ensuring that they are firing at the correct times. At

Ryan Bratten
A2 Technology
Drill Bit Sharpener

Modifications after Manufacture

This image displays all of the modifications after manufacture. On the left hand side of the product you can see the new positioning of the Circuit board water pump. Because of their new positioned this allowed the base to be changed which made the overall size of the product a lot smaller and more compact than it had been. The colour scheme was also changed.

This view shows the final two modifications to the marble race and the extra supports given to the sharpening bit and also the bracket that it sits inside. This was done using seven carbon steel metal rods to stop the bracket from twisting with the sharpener

This image shows in more details the final two modifications to the stepper motor bracket and to the marble race. The marbles here have been given their own hole in which to rotate instead of the long strip that all of the marbles where in. This new design stops the marbles from jumping out of their race when the product is moving. It also makes sure that ever marble is rotating allowing a smooth motion for the product

MODIFICATION 1: BASE

This modification allowed the base to become a lot smaller thus allowing the product to be far more compact than it had been before as I felt that the product was slightly to large to be cared about a lot and the users arms and body would soon take the strain

MODIFICATION 2: WATER PUMP

This was to change the positioning of the water pump to accommodate the new base

MODIFICATION 3: CIRCUIT

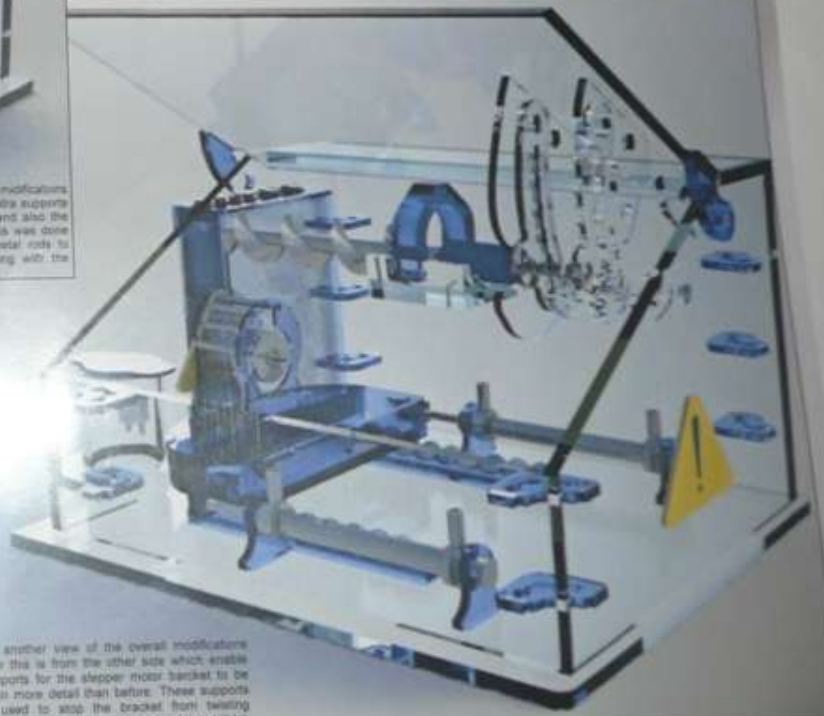
This modification was to change the positioning of the circuit cover from being laid flat on the left hand side to being sat upright and upright against the wall of the outer case. This allowed the overall size of the product to be reduced as I thought it was too big to be carried around

MODIFICATION 4: SUPPORTS

This modification is the supporting beams or rods added to the stepper motor bracket. This modification was necessary to stop the bracket from twisting whenever the sharpener came in contact with the drill bit. If this continued the bracket would of eventually broke

MODIFICATION 5: MARBLES

The marbles at first where placed in a slot within the outer race however this allowed the marbles to move too much and sometime they managed to jump out of their race and then they would have to be replaced. This modification stops them from doing this



This is another view of the overall modifications however this is from the other side which enable the supports for the stepper motor bracket to be shown in more detail than before. These supports where used to stop the bracket from twisting whenever the sharpener twisted around that drill bit

Ryan Bratten
A2 Technology
Drill Bit
Sharpener

Image Gallery

Ryan Bratten
A2 Technology
Drill Bit
Sharpener


Centre no 71571
Card no. 4025
A2


Candidate No: 8007
A2

Introduction

Problem

In 2009/10, there were 4,018 reported cases of theft from motor vehicles in Northern Ireland (PSNI Crime Statistics), while there were 2924 cases of vehicle theft. The detection is far lower for theft from vehicles due to the quick smash and grab nature of the crime as shown by the 3.5% detection rate compared to the 27.3% for vehicle theft, which shows that many car alarm systems can really only protect against a minority of thefts. Due to the new sophisticated nature of anti actual car theft, the rate has fallen but the rate of theft from cars has risen from 3,823 in 2008 to 4,018 in 2010. This is due the lack of anti theft devices within cars that are fitted as standard, most people do not realise that it is in fact very easy to break into a car and get away quickly and not be caught or detected. The most frequently stolen items from a car include laptops, wallets, stereo systems and surprisingly air bags due their portable nature .Most thefts occur at night due the poor visibility and that cars are most abundant at this time due to people being home from work and this can provide providing anonymity to the offender due to the high volume of people that would be present in the street. Location is also a factor due to the atmosphere of the neighbour hood that the car owner lives in, if the said car owner lives in a quiet residential areas they may be lax with car security and leave the car unlocked, a perfect target for a thief, although most car crime occurs in streets in a city/town, a massive majority of thefts happen in streets and the people live in this area would be the best target audience for my product.

Design Brief

I intend to design a product that would successfully deter a thief from taking anything from a car or to supplement the cars existing alarm system. I also wish for the product to have a variety of detection features, be it to be able to sense a broken window, a car stereo being removed or a door being opened. The product must be able to fit in with all car interior layouts and not attract attention , for example it must be placed in a discrete location, which is out of sight. It must be sealed to prevent access except in emergencies. I would also intend to design it so that it could run off either the 12V car battery or a smaller battery inside the case.

Specification

Function

- Must be able to detect an intruder in one or more ways
- Must sound an alarm, that will alert either passers-by or the user that the car has been broken into
- The alarm must be able to be turned off by a remote or a code on a keypad on the main casing
- Must run off either the car battery or a 9V battery

Safety

- There must be no loose wires, as these could cause the user or passenger to be electrocuted
- No sharp edges must be present as these could pose a serious injury risk to a person in the car
- Must be able to cope with a car battery current without over heating

Materials & Processes

- Must be made from materials that are hard and durable
- Materials must be in a neutral colour
- The product must be made from materials that are available in school
- The product must be made using processes that are available inside school, which are laser cutting, a CNC router, vacuum forming and lathing
- The materials must not be exuberantly expensive, for example silver or aluminum alloys

I will have to consider many materials for use in my projects but the main material, which would be used in the casing of the product would have to be hard wearing, either have a existing neutral colour or be able to finished in one, some of the materials taken into consideration include:

ABS – This plastic can be easily shaped via various processes such as vacuum forming and it can be laser cut. It is a hard wearing plastic, which will not shatter or scratch easily

Steel – Steel can be bought in various forms like bar, sheet and rod, which allows a wide range of shapes to be made.

Ergonomics

- Remote must fit comfortably in hand
- Remote easy to use and buttons clearly labelled
- Keypad must be a suitable size and easy to reach
- The product must be easy to install in any type of car

Performance

- Must be able to withstand a fair amount of force
- Must not be easy to take apart
- Must not drain the car battery or 9V battery by a substantial amount

Aesthetics

- The product should not draw attention to itself, as it is a security product
- It should not look out of place in any car interior design, regardless of colour or space
- The main casing should be made from a material that reflects a high quality, as it will be competing against other products in the market

Physical Proportions

- Must easily fit in an out of sight place, e.g. under a seat or below the glove compartment or 250mm x 250mm x 150mm.
- Must not weigh more than 1 kilogram
- Remote must not more than 100mm x 75mmx 50mm
- Remote must not weigh more than 0.5 kilograms (500 grams)

Environmental Concerns

- The materials used in the construction of the product must be environmentally sustainable by being recyclable, and if possible be from recycled material.
- If the product ran off batteries, there should be a label to advise the user to use rechargeable batteries or recycle the old ones

Quality

- The edges of the product must be finished to a high quality suitable for retail
- The soldering done on the circuit of the product must be done to a high standard to minimize chances of electrical failures
- There must be no visible or distinguishable marks on the outside surface of the product that would reflect badly on it

Research

For my problem, there are several existing products that provide a wide range of functions. These range from a very modest £49 up to a substantial £2000. The main features included in most of the products are shocks sensors to detect if someone has hit the car, reed switches for the doors and boot and central locking for each of the doors.

Streetwize Car Alarm

Description	This product is a very simple, low end item as it only has a restricted amount of features
Features	Shock sensing. 120db siren. One wire connection to car battery Adjustable sensor control. Key fob
Materials	ABS
Processes	Injection Moulding
Cost	**£49.99**

In my product I plan to incorporate a wireless remote to activate and deactivate the alarm from a distance. The two possibilities for this are infrared and radio
Infrared data transmission is employed in short-range communication among computer peripherals and personal digital assistants. Remote controls use infrared LEDs to emit infrared radiation which is focused by a plastic lens into a narrow beam. The beam is modulated, i.e. switched on and off, to encode the data. The receiver uses a photodiode to convert the infrared radiation to an electric current.
Radio control uses a transmitter, which sends out a radio signal of a pre determined frequency e.g. 35MHz to a receiver. The signal is detected by the receiver which then sends a control signal to the output, it is used in many applications including toy cars. The advantages of infrared is that the circuitry required is a lot less complex that radio, it is also cheaper to make and has a lower power consumption. Although infrared requires a direct line of sight to function whilst radio can work up to tens of meters with an obstacle in the way. I feel even though that radio is more complex and is more expensive, it is more suitable for my project due to the way it functions.

Another feature that I plan to include, is a way of fixing the main alarm casing to the interior of the car. There are numerous ways of solving this problem including Velcro, screws and magnets.
Velcro consists of two layers: a "hook" side, which is a piece of fabric covered with tiny hooks, and a "loop" side, which is covered with even smaller and "fairier" loops. When the two sides are pressed together, the hooks catch in the loops and hold the pieces together.
For my project I feel that magnets would be best as they provide an extremely strong hold and require only a small space to attach onto.

Hornet Maxx 1

Description	This is a mid range product suitable for many cars, it has a fairly wide range of features, which protect a variety of entry ways into the car
Features	Back-up Siren Door/boot & bonnet protection Ultrasonic Sensing LED Status Indicator Valet Mode Central Locking Door Locking Relays 2 Remotes
Materials	ABS Steel
Processes	Vacuum forming Injection Moulding Rotational Moulding
Cost	£180

Avantguard 5

Description	This is a top of the range product as reflect by its £1000 price tag. Its wide variety of features allow the user to adjust their security settings accordingly
Features	Remote Siren Silencing Siren 2-point immobilizer Wiper Control Windows Up Door Locks Wireless Immobilizer Remote Start Safety Shutdown Switch
Materials	ABS Steel
Processes	Vacuum forming Injection Moulding Rotational Moulding
Cost	**£999.99**

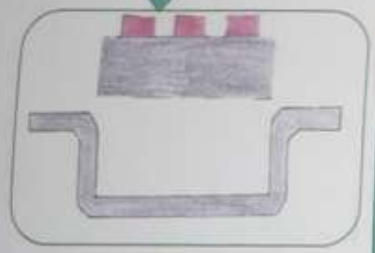
Product	Design of Product / Structure	Effectiveness	Aesthetics	Value for Money	Summary /25
	Large fins & is very basic product, the quality of manufacture is fairly low as the product has been quickly mass manufactured. ☆☆	The siren itself is incredibly loud, which is a positive point although its detection capabilities leave a lot to be desired. ☆☆	The aesthetics on this product are quite poor as since it will not be seen, the designer has placed function over form. ☆	Its price its reflects its quality, at only £49.99, it is a low end product whose features reflect this, although it is basic, it is effective. ☆☆	10
	This product is fully capable of holding its own in the market as its features cover a wide range including door & boot protection. ☆☆☆☆	The quality of this product is quite high even though it is a mass manufactured item. ☆☆☆☆	When it detects that one of its sensors has been broken, it activates it loud alarm, with a backup if the first one fails. ☆☆☆☆☆	The aesthetics, which feature on this product are quite basic but works quite well. ☆☆☆☆	This product is incredibly good value for money at only £100, it has a great price to feature ratio ☆☆☆☆	21
	This product is exceptionally fit for purpose as it has a massive variety of functions that are capable of dealing with virtually any threat to the car. ☆☆☆☆☆	The high quality of this product makes it feel very secure and justifies its price tag. ☆☆☆☆☆	Its many features allow to be remotely locked and immobilised, therefore preventing many thefts as well as its main alarm ☆☆☆☆☆☆☆☆	The designer of this product has obviously thought above the looks of this product as exceptionally eye pleasing ☆☆☆☆☆	At almost £1300 pounds, the price makes it extravagant although it does not deserve the extra price due to a limited amount of extra features. ☆☆☆	22

Concept One

The keypad I plan to use in my project , is a standard matrix 3/4 digit keypad, like the one shown to the left . It will be used to activate and deactivate when the user does not have the remote

The product would be made out of two different vacuum formed moulds with a lip on each one, then two identical layers of acrylic laser from a sheet would be placed on top then four machine would be placed through holes in each corner to secure the product. Each of the inputs will be connected by a 7mm jack into separate sockets allowing easy installation

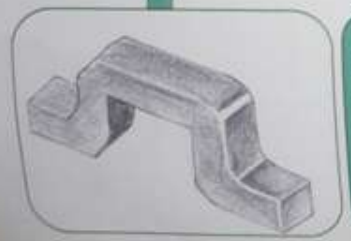
The handle will be used to move the product to and from underneath a seat in the car for ease of installation and repair



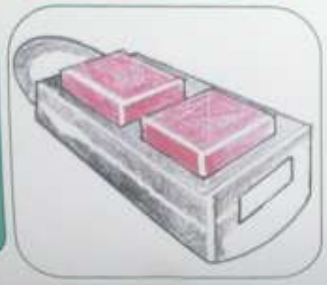
I plan to fix the keypad to the top half of the casing using a specially made holder. The keypad will slot into the holder and will be secured by tensil cement

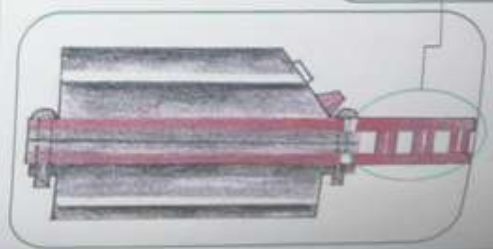
I would create a remote for use in this product, to arm and disarm the the device from afar. It would be made from two vacuum formed moulds with a keying add on at the back possibly made from layers of acrylic or aluminum

The drawing below shows how the product would fit together and the close up on the right shows the simple design required for the handle



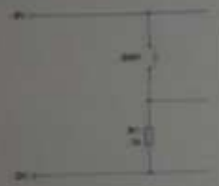
The holder I plan to create will be made out of a sheet sheet of line bent acrylic that will will around the keypad and will be glued onto the inside of the casing





Mark Campbell Car Alarm Friends' School Lisburn

Circuit One



This how I would wire the PTM switches on the remote, with a pull down resistor, the output of this would then go to the PIC

Input

Either the keypad or the remote can be used to arm the alarm, by the means of two toggle switches on the remote or by entering the correct four digit code on the keypad.

Control

A PIC in the main casing will process the inputs, while several other PICs will operate outside of the main casing, in the remote and driving each of the IR LEDs in the car.

Output

When the product is armed and either of the IR beams are broken or a reed switch is disconnected, the siren will be activated until such a time that the correct code is entered on the keypad.

Remote

ARM/DISARM PTM switches

PIC

IR LED

Main Casing

Keypad

IR Photo Transistor

PIC

Buzzer/Siren

Sensor inside car

IR

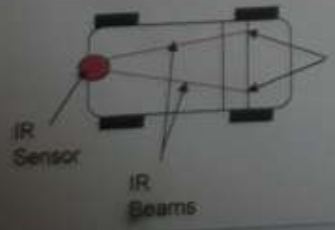
Photo Transistor

IR LED

IR LED

I plan to use a PICAXE 28A (shown to the left) in the circuit, due its high number of I/O pins. I need the output pins for the siren and keypad, while the input pins will be used by the photo transistors, keypad and reed switches. The program that I would use would have to include control the photo transistors quite possibly like the example below and to the left.

I plan to use several IR LEDs like the one shown above to detect someone entering the car. I would arrange them in a fashion like in the diagram below with one IR sensor and two IR sources so if either are broken, the alarm sounds.

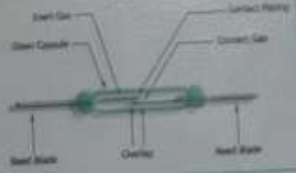


IR LEDs

IR Sensor

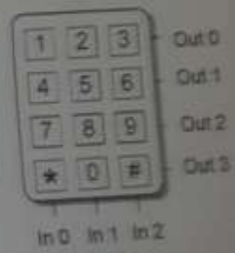
IR Beams

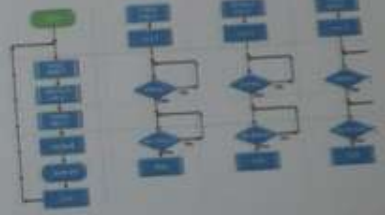
Reed Switches



I plan to attach five reed switches, one to each door and then the boot, I will then place a magnet on the car body itself so that when the door is opened, the connection is broken and the alarm sounds.

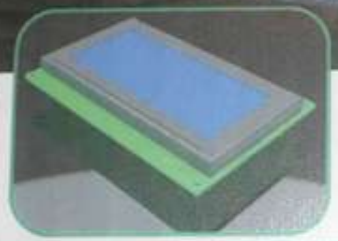
To the right, is the style of keypad that I will use called a matrix keypad. Instead having twelve different switches for each digit, the columns are wired to the output of the PIC while the rows are wired to the inputs of the PIC so it requires a significantly smaller amount of inputs.

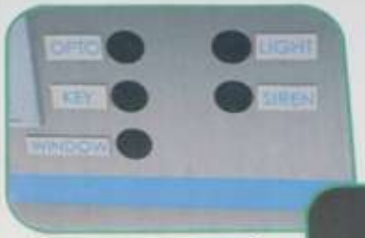




Concept Two

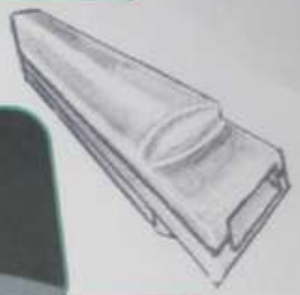
This shows all of the main parts of the product, the main casing, key and arming device. The sides of the main casing will be made out of several layers of laser cut layers of plastic while the back while be made out of a shaped piece of plastic. The front and bottom plate will be made out of sheet steel.



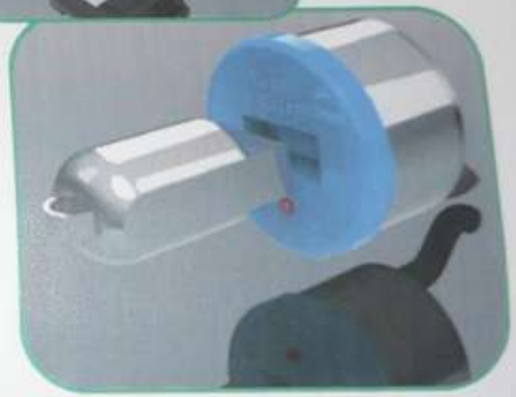


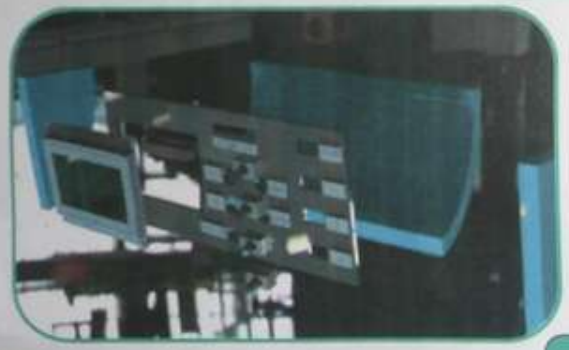
Above shows the three inputs and two inputs used in the product

The drawing to the right shows the key fob that will be used in this design. It will be slim to fit on a key ring. It will be made from two symmetrical vacuumed formed halves.



The drawing to the right shows the arming device. It would be made out of steel for the main body and back plate. The front face would be made out of vacuum formed plastic. When the [illegible] is inserted into the [illegible] works [illegible] the [illegible]





The slide switches that I am using in this design act like a keypad in the sense that the user has to slide the bottom three in the correct order to arm/disarm the product. The top one is slide across to start the sequence

To the right shows a reflective optoswitch, I plan to use these in this design to detect if the door is closed or open. I plan to place an optoswitch on each door, and a strip of sheet aluminium on the door so when the door is closed the IR beam is reflected and the switch is closed

Mark Campbell | Car Alarm | Friends' School Lisburn

Circuit Two

The IC I intend to use in the key fob is a 555 timer configured in an astable mode. When the remote is inserted into the arming device it completes the circuit and causes the 555 timer to start pulsing.

When the 555 timer starts pulsing, its output goes into a PIC in the arming device. If the correct sequence is received, the PIC sends a signal to the main PIC in the body, which arms the product. the PIC in the arming device then turns on a LED to show that the device is armed.

Input

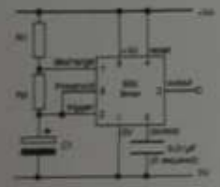
By inserting the key fob or entering the correct sequence of slide switches, the user can arm the device. When a window is broken or a door is opened, the respective vibration sensor or optoswitch attached to that window or door registers it and sends a signal to the PIC.

Control

A PIC in the main casing will process the inputs, while several other ICs will function outside of the main casing, in the key fob and in the arming device will provide secondary functions

Output

When the PIC in the main casing receives the signal from an optoswitch or vibration sensor, it then sounds the alarm and powers on the security light. This will last until the power is reset or the correct code is entered.



Key Fob

555 Astable

Arming Device

LED

PIC

Main Casing

Shock Sensors on each window

Battery Life LED Array

LM3914

Battery

PIC

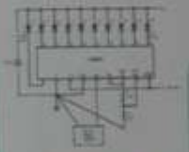
Slide Switches

Siren

Security Light

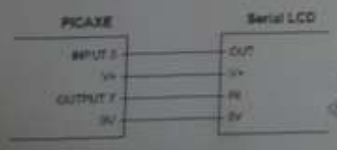
AXE033 → LCD

The LM3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating the need for resistors. This feature is one that allows operation of the whole system from less than 3V. To the left shows how I would connect the LM3914 in a circuit



An optoswitch consists of an infrared LED and a phototransistor combined in a single package. The phototransistor is arranged so that it can detect the infrared from the LED. In the case of the reflective optoswitch the infrared beam is only detected by the phototransistor if it is reflected by an object close to the switch. Below shows what an actual optoswitch looks like and how to connect one in a circuit. The pull up resistor on the transistor side cause s the output to stay high when the a piece of metal is placed near the

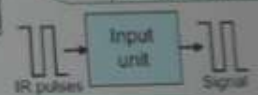
As the PIC cannot directly drive the LCD itself, it has to go through another IC the AXE033 which converts the signal from the PIC to an output on the LCD. To the left shows an example program which would display the value of a variable on the LCD and below shows how to connect an LCD to the AXE033.

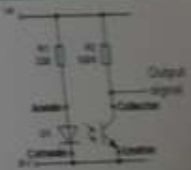


I plan to use a Liquid Crystal Display (LCD) in my product which will display, along with other things such as the time and how long the user has left until the alarm sounds, if the device is armed or not.

Optoswitches on each of the doors

To reduce the number of inputs needed, I would pass each of outputs from the optoswitches through a series of OR gates like the one on the left so the inputs needed fall from four to one.





Mark Campbell — Car Alarm — Friends' School Lisburn

Concept Three

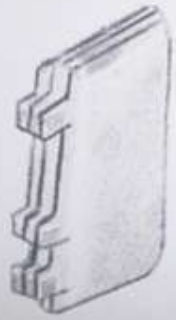
This product is designed to clamp onto the steering wheel of a car using a rack and pinion mechanism to secure it. The bottom piece of the main casing will be made from fabricated sheet acrylic, while the top while be made from a CNC vacuum formed mould.

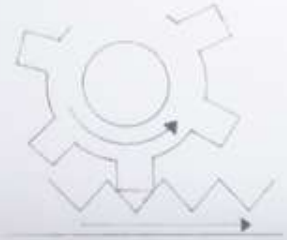
I plan to secure the product with screws placed in four locations around the base. These will hold the product together even when the mechanism is operating.

I plan to secure the product with screws placed in four locations around the base. These will hold the product together even when the mechanism is operating.

To secure the product to the steering wheel, I plan to use clamps, like the one shown to the left.

I plan to use a card in this design to arm and disarm the device. It will be inserted into a slot on the front face of the product. It will be constructed out of three layers of sheet steel.

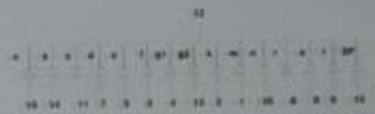




To secure the rack and pinion mechanism I plan to manufacture a case that encloses the gears but allows the motor to rotate the central keel. The cases will be made from a vacuum formed piece of acrylic and fixed to the base via crews inserted through support rods.

To reduce the amount of inputs needed for the series of optoswitches I plan to plan them through a series of logic gates to form one digital output, like the the left, this allows other inputs to be used by other sources and reduces complexity in the programming of the PIC

I plan to use a sixteen segment display in the design to show whether the device is armed or disarmed by displaying an A or a D respectively as shown below. To operate the display, a separate IC is needed, and this IC is the MM5484. the MM5484 is designed to drive common anode separate cathode LED displays. The pin layout of the MM5484 is shown below



To arm and disarm the device, a card will be inserted into a corresponding slot in the main casing. The card itself has a series of extruded segments which, when inserted will block several slotted optoswitches. There will be a number of optoswitches of which, only some will be blocked, this leads to a unique sequence that will be sent to the PIC

PIR sensor

Main Casing

Card

Sixteen Segment Display

Optoswitches → PIC → Thyristor → Siren

Tilt Switches

Potentiometer

Dual Motors

To extend and retract the racks, I will use two motors from each one, when the device is armed the racks are locked in place and can not move as stop and intruder taking it off.

The owner can control the length of the racks by adjusting the potentiometer on the front of the device. To control the motor I plan to use a L293D chip, which allows control of one or two motors and is connected as follows

To prevent the device from being removed from the steering wheel, I plan to use two tilt switches, one placed vertically and the other placed horizontally so that when the device is tilted, the contacts are connected and this then sends an high signal to PIC

Input

When the card is inserted, and the correct sequence of optoswitches are blocked, a high pulse will be sent to the PIC. When the device is armed, and it is moved, the tilt switches' contacts will connect and send a pulse to the PIC

Control

The only PIC in the circuit, processes each input and decides whether or not to sound the alarm due to the programming

Output

When the PIC has received an input that signals that the correct sequence of optoswitches has been blocked, it arms the device and displays a D on the sixteen segment display. If a signal is received from the tilt switches or the PIR sensor, it sounds the alarm

The potentiometer will be wired using all three of its connections, using the wiper as the output. In this way it acts as a voltage divider as shown to the right. The PIC will scan the input that the potentiometer is connected to for any change, which would result in the lengthening or shortening of the racks.

The PIC I plan to use in this design is the PICAXE 18X. This type of PIC has sufficient inputs and outputs to allow my design to function properly. Although only three of inputs and three of the outputs are needed, the 18X is smallest IC that will accommodate this. Below shows the PIN layout of the PIC

I plan to use a PIR sensor mounted on the dashboard to detect any movement inside the car. A PIR is an electronic device that measures infrared light radiating from objects in its field of view. Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature.

Circuit Analysis

Fitness For Purpose – This circuit is very suited for its purpose as it can detect an intruder in many different ways, as it can detect the doors opening via the reed switches or when someone enters the car by the two IR beams. It is also very secure as someone has to have the remote to arm or disarm the device, but they have to know the code if the alarm sounds. The alarm will latch due to the thyristor which means even if the door is closed or the beam becomes uninterrupted, the alarm continues to sound because of its latching nature.

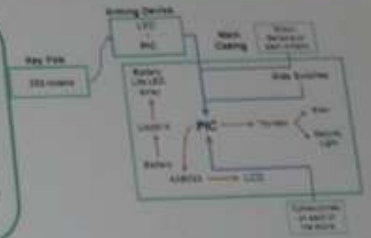
Reliability and Complexity - This circuit is fairly reliable as it mainly depends on the PIC program and a small amount of complex components, although the logic gates used to reduce the number of inputs introduce some complexity. One problem is that if the IR LEDs get knocked out of place or broken, the detection capability of the product would be severely reduced

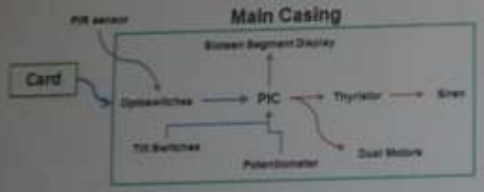
Program and Size – The program on the PIC in this circuit would be fairly complex as it would have to take into account the keypad and the various inputs and outputs. The circuit would consists of two PCBs, one in the remote to act as the transmitter in the IR circuit, and the main PCB casing that would act as the receiver and contain the main PIC.

Fitness For Purpose – This circuit is fairly well suited for its purpose as not only can it detect someone opening door unauthorized but it can also detect a window being shattered, this is because of the reflective optoswitches on the doors and the shock sensors on the windows. There is a main PIC that controls and monitors all inputs and outputs. There is an added feature in that there is a battery life indicator, which is helpful for the user. The LCD shows if the device is disarmed or armed and also shows how much time is left before the alarm sounds. The disarm code can be entered by correctly sliding the switches in a specific manner . The key fob is used to disarm or arm the device and is mounted on the dashboard.

Reliability and Complexity - This circuit is fairly complex and therefore ,not very reliable as there a lot of components to trouble shoot if something goes wrong , there are three PICs in total in the circuit , one in the arming device and two in the main casing, this adds to the complexity, and as with the first circuit there are logic gates to reduce the number of inputs.

Program and Size – There are three main circuit boards and one minor one, the minor one is the LCD PIC which requires a mount of its own. There will be one circuit board in the key fob to house the 555 timer and one in the arming device and the major PCB in the casing which houses all of the main components. The program will be very complex as, it will have to interface between three PICS and several other components

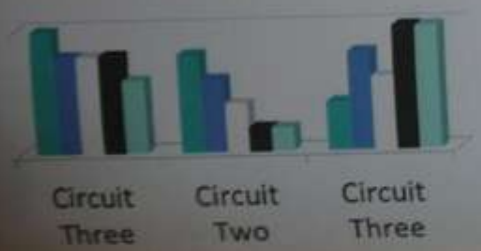




Fitness For Purpose – Since this circuit has only one way of detecting a intruder, it isn't perfect for its purpose, but the PIR sensor is very effective and will have very few false alarms . When the key is inserted it will activate a certain series of optoswitches to arm or disarm the product. Depending on the state of the device, the sixteen segment display will show either an A or D to show the user that the device is armed or disarmed. The rack and pinion mechanism is used to secure the product to the steering wheel of the car so that it acts as a visual deterrent as well, if the product is tilted at all when alarmed, it will sound as the tilt switches inside the casing will have been activated.

Reliability and Complexity - This circuit is very simple and reliable, consisting of a small amount of non complex components to achieve its function, although keeping the rack and pinion mechanism locked is fairly tricky. [illegible] to simplify the input from the optoswitches into one digital signal.

Program and Size – The program in this circuit is also very simple, [illegible] no complex procedures that need to be followed except the output to the sixteen segment display driver and the output to the motors. There will [illegible] in this circuit, although the bulkiness of the rack and pinion takes up most of the space inside the casing.



Circuit	Fitness for Purpose	Reliability	Size	Complexity	Program	Overall
Circuit Three	5	4	4	4	3	20
Circuit Two	4	3	2	1	1	11
Circuit Three	2	4	3	5	5	19

Conclusion

As the table shows to the left, Circuit One scored the highest with 20/25 although there is room for a lot more improvement, Circuit Three was not that far behind on 19/25 and Circuit Two was last with 11/25. Circuit Two had many features that would make it a good product although realistically it would be very difficult to manufacture due to its complexity. Circuit Three was very basic although it would work, just not as well as the others. I have chosen to develop Circuit One for my project although I will incorporate other features from the other two such as the LCD screen from Circuit Two and the tilt switches from Circuit Three.

Design Analysis

Concept 1

Materials and Manufacture – For this design I plan to use ABS plastic. The top and bottom layers will be made from black ABS, while he middle two layers that hold every together will be made from laser cut acrylic. I am using these materials as they offer good damage resistance and aesthetic properties and are widely available. The whole casing will be secured together by four screws place in each corner of the body.

Function –The product has the ability to monitor and detect several ways of intrusion into the car, one of the ways are reed switches on every door so that if one of them is opened when the product is armed the alarm will sound or if something breaks one of the two infrared beams. The jacks on the front allow quick and easy installation for the user and the remote allows the product to be disarmed/armed from afar.

Performance and Physical Proportions– This product is fairly robust although since it made out of plastic , it would not be able to withstand a substantial amount of force . It will not drain the battery or power supply as it has no displays , although when sounded it has a siren which, will drain a substantial amount. Its size allows it be to be placed under a car seat and easy moved about in the car whilst the remote is small and light enough to either carried on its own or attached to a key ring.

Aesthetics and Ergonomics – The aesthetics of this product are outstanding, as both remote and casing look as if they belong together. Even though the product is designed to be hidden out of sight, the ample red and black colour scheme give the concept a very professional and sleek look whilst not being so attention grabbing that it would be immediately noticed in the car. The handle is suitably designed so that the majority of hand sizes can hold it and the jack socket inputs/outputs allow even someone that is not electronically educated to install the device.

Concept 2

Materials and Manufacture – In this design I plan to use steel and acrylic to manufacture the product. I am using steel because it has an impressive strength to weight ratio and allows the product to withstand a lot more force and pressure than the last design, while the acrylic sides and back add to the aesthetics. I plan to manufacture the sides from several layers of acrylic to reinforce the structure and the back from heat shaped acrylic. The front and top faces will be manufactured from sheet steel. The key will be fabricated from a single piece of steel whilst the back and cylindrical part of the arming device will be made from steel sheet and tube respectively, the front face made be made from a vacuum formed mould.

Function – This concept is able to detect several entryways into the car including reflective optoswitches on each of the doors and photo sensors on the windows. The current state of the device is displayed on an LCD screen and it can be armed and disarmed by inserting a key into a specially made arming device to go through the correct sequence of tilt switches. An added features of this concept include a battery life indicator and a security light inside the car, these both add extra functionality to the product.

Performance and Physical Proportions– This product is very durable as the steel and multiple layers of acrylic make for a [illegible] the alarm it need to be on all of the time. Its size allows the product to disable the alarm, the power consumption however will be a lot greater due to the LCD screen, which also [illegible] and the key is compact enough to fit in a pocket. the product to be mounted under the glove compartment or elsewhere in the car, while the arming device is the right size to [illegible] which can not be shaped as easily as plastic and it is a more function over form product. Although the Key would fit well in the hand due to its curved design and [illegible] bezel feature.

Concept 3

Materials and Manufacture – For this product I plan to [illegible] be vacuum formed to create the top layer and fabricated to create the bottom. The rack and pinion mechanism will be made from steel and the interior [illegible] acrylic to give continuity through out the product. The key will be made three layers of sheet aluminum as it is light, can be easily shaped and can be produced [illegible].

Function – This concept can only detect one possible [illegible] although if the product is moved the alarm will sound due to the tilt switches inside the casing. The locking mechanism is a feature that is has over the other two products [illegible] without the alarm going off. The sixteen segment display also allows the user to see if the product is armed or disarmed by displaying an A or a D respectively.

Performance and Physical Proportions– This design is weakest structurally of the three, as the hollow case offers very little resistance to a force directed at it, while it will be able to withstand the occasional knocks a blow would easily break it. Due to the locking mechanism, IR[illegible] sensor and sixteen segment display the concept will draw a considerable amount of power, which will mean that it will have to run off a car battery with a 9V battery as a backup. The product is designed to fit across the steering wheel and so is designed accordingly and they key can easily fit on a key ring or in a pocket.

Aesthetics and Ergonomics – This concept has fairly good aesthetics, better than concept two but worse than concept one. The overal shape is an eye pleasing and suitable shape. This concept also acts as a visual deterrent, so that any potential intruder will see it and know that there is a security system in place. The product is very ergonomical as the rack and pinion mechanism is easily adjusted through the switch on the front and the product is easily set up.

Concept One | Concept Two | Concept Three

Concept	Function	Performance	Aesthetics	Ergonomics	Materials	Overall
Concept One	5	4	5	5	3	22
Concept Two	4	5	3	4	5	21
Concept Three	4	3	4	4	4	19

Conclusion

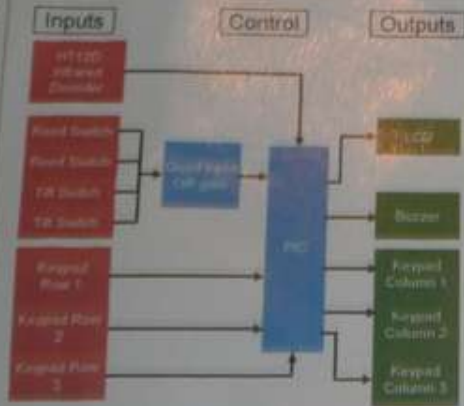
As the table shows to the left, Concept One scored the highest with an impressive 22/25, even thou it is the highest it still an be improved upon. Concept Two was very close with 21/25, although its aesthetics were its failing point. Concept Three, although it was the weakest of the three designs, it still had some ideas that can be used in the final design. Through comparing and contrasting the three concepts I can conclude that concept one will be the design that I will carry forward and develop further although I may include features from the other two ideas.

Circuit Development

In the main casing, there will be two tilt switches placed along perpendicular axis, to detect any movement of the case and two reed switches on the door to detect whether or not the door is open. All four of these inputs will then be run through a HCF4071BEY quad input OR gate to form one coherent output which will then be fed into input 6 of the PIC to create a signal that will go high when ever any one of the four inputs goes high.

The infra red receiver will be placed on the front of the box so it receives the best signal from the remote. The HT12D receiver IC decodes the signal produced from the transmitter and will output a high or low signal depending on if there is a valid transmission through pin 17, this will then be fed into pin 7 on the PIC, this will determine the alternate action method as described before.

Block Diagram

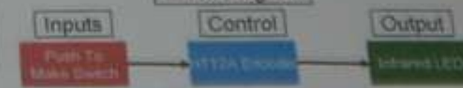


The PIC I have decided to use for my final circuit is an 18X. I have used this because it is the smallest PIC that I can use that will accommodate all of my inputs and outputs while still being able to fit a complex program on it, to control the circuit.

When the device is first started up, the initial state is that it is disarmed, this is shown on the LCD. What is shown on the LCD will vary on the state of the device. When any of the sensors are activated and the device is armed it will start the alarm sequence and a countdown will begin on the LCD after 3 seconds the alarm will sound and continue to until the correct code is entered on the keypad. If the user enters the wrong code they are temporarily locked out for 10 seconds and if they enter it wrong three times in a row, the device will block anymore attempts and a reset will be needed via the key switch.

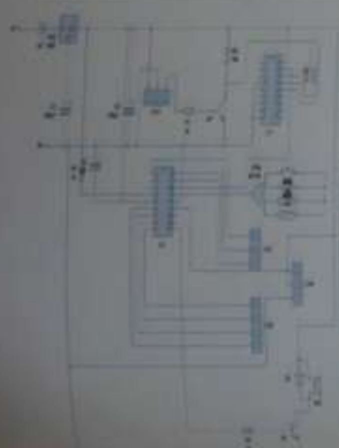
For my product, I have decided to use a remote to arm and disarm the device from afar, the transmitter circuit will be placed in the remote and will operate via a alternate action mechanism, where only one push to make switch will be included in the circuit, so that when the switch is pressed the state of the device will change, from armed to disarmed or vice versa.

Block Diagram



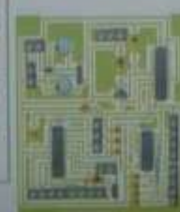
To get the remote as small as possible, I had to design the PCB layout myself and not use the Autoroute feature as the smallest size was 3inX2.5in shown top right and my design, which was 3.8inX1.3in is shown to the right.

I decided on using coin cells in the remote instead of a normal 9V battery to preserve space to make the remote as small as possible.



To develop the PCB for this circuit I had to design it on a program called CircuitWizard which allows the user to create and design circuits and PCB layouts. The circuit is shown to the left. Due to the complexity of my circuit I was not able to use the built in Autoroute feature to create a compact enough PCB for my product, the smallest size I was able to produce was 5.8inX5.8in, which is shown to the right.

Instead I had to manually create the layout and I was eventually able to reduce it down to a size of 3.8inX3.8in, which was small enough for my product as size is paramount in this project.



The next stage was to test the circuit on a prototype breadboard shown below. This was to test if the circuit would work in real life. On the left hand side of the board is the infrared receiver, which then linked to the PIC on the right. The LED is to stimulate the alarm. On the bottom is the quad OR gate which is fed into the PIC as well.

After I had built the circuits on a breadboard and checked that they were working, I constructed the PCBs from the layouts that I had designed on the computer. I then soldered each component and checked that each circuit was working and below are the two final circuit.

Main Circuit

Remote

Breadboard Testing

From the datasheet for the infrared LED, I can calculate the minimum resistance required to protect the IR LED from harm.

Supply Voltage = 5V

Forward Voltage across the LED = 0.7V

Maximum Current Through LED = 20mA

$V = 5 - 0.7 = 4.3$

$V = IR$

$4.3 = (20 \times 10^{-3}) \times R$

$R = 4.3 / (20 \times 10^{-3})$

$R = 215\Omega$

From the two pictures below have shown that when the wires are not touching, that are acting as the push to make switch, the voltage across the LED is zero, but when they are touching it is 0.72V.

This shows the quad input OR gate, the two reed switches and two tilt switches will feed into, when any one of the four inputs go high, this then causes an high output signal to be fed into input pin six on the PIC. Along with the program on the PIC, it allows the product to continuously check for any change in the switches.

This is the HT12D [illegible] when used in conjunction [illegible] transmitter can transfer [illegible] range. When data from [illegible] to an HT12D, it checks [illegible] pins on both chips match [illegible] seventeen on the HT12 [illegible] am using in my project to [illegible] pin seven on the PIC.

When the alarm has been triggered the user is required to enter a three digit code to disable the alarm. If the user enters it correctly the alarm is disabled and everything is reset. If the user enters the wrong code, a lock out occurs for ten seconds, as shown. If it is entered wrong three times the user is fully locked out and a power reset is required.

To the right shows the buzzer that will sound once the alarm has been activated. It is currently switched on as shown by LCD and the voltage on the multimeter..

LCD

This program controls two of the messages that the LCD can display. They are either "Alarm Disengaged" or "Alarm Engaged". They depend on the what the variable C is. If C is one then it displays "Alarm Engaged" and if it is zero then it says "Alarm Disengaged". The variable H is used to stop the display from flashing the same message repeatedly. As when the program it runs through once, H is set to either one or zero so that if goes down the same path the next time. It ends and there is no new command sent to the LCD.

Below is the main keypad program, when it starts by defining three variables G, which is used to count how many times a wrong code has been entered, A, which counts indicates if a wrong digit has been entered and F, which is used in the key display program. The next command displays "Keys Entered" on the LCD and then goes to the FIRST DIGIT sub program, which checks what key has been pressed, then it runs the KEY ENTERED sub program which then displays what key has been pressed. This process is then repeated twice more to get the three digit code. If D is greater than or equal to two, the program enters an infinite loop, whilst displaying "Too Many Wrong Codes Entered. Reset Needed". While if D is less than two it then checks the variable A to see if a wrong key has been pressed, if the comparison is true, the LOCK OUT sub program is run and D is increased by one. If A is equal to zero the alarm is turned off and the message "Alarm Disengaged" is displayed on the LCD and the whole program starts again.

Keypad

This is the PIC program that I will use in my final product, I plan to use only one PIC in my final circuit as this is all that is needed. The program is fairly complex and uses all of the inputs and most of the outputs available on the 16X IC. It controls all aspects of the circuit including the LCD, keypad, sensor used and uses 1100 bytes out of 2024 that are allowed on the PIC. There are a total of nine sub procedures to control the various components.

Variables	A	B	C	D	E	F	H
Use	Incorrect Digits	Alarm Time	Armed Indicator	Incorrect Codes	Locked Out Time	Key Display	Prevents Repeated Messages

Lock Out

This LOCK OUT procedure comes into use when the user enters an incorrect code on the keypad. It starts off by assigning the variable E a value of ten. This variable will be used as in a timing series of commands and also to display a countdown on the LCD. There will be a message displayed on the LCD saying "Wrong Code Entered". There will be a wait to allow the user to read the display and then it will move onto the actual lock out sequence. It consists of the LCD first displaying "Locked Out", then on the bottom line it will display "Returns in [E]" where E is the time remaining. It starts off at ten and is deceased by one every time the loop cycles, there is a wait command for 0.94 seconds to bring the total wait to one second. Once E is equal to zero the program exits.

Alarm

This sub program is used to control the alarm part of the system. The variable B is used as a count down on the LCD. The command used is Alarm Activated in [B], this means that as the sub program runs once the variable B is decremented by one until it reaches zero from its starting value of three. I have used a wait of 0.94 seconds because after each LCD command I have to include a 0.03 second wait to allow for the command to be fully received by the display. After three cycles or three seconds the sub program proceeds to sound the alarm and display a new message on the LCD, Alarm Activated.

Start

This is the starting program for my circuit. It starts by assigning C a value of zero and H a value of one. The program then has to wait for 0.5 seconds to allow the LCD to initialise. The initial state of the device is that it is disengaged. The cell 'Enable Interrupt' allows the interrupt procedure to occur at anytime. The program then loops the two main procedures of ARMING and LCD until the device is armed or the interrupt is triggered.

Interrupt

This interrupt procedure is important as if one of the four sensor switches are triggered no matter where/how/why the program is running, it will jump to this procedure. The alarm if checks C, as defined in the ARMING program, if C is equal to one i.e. the alarm is engaged it runs the ALARM and then KEYPAD procedures. If the correct code is entered, the alarm is turned off and the system is disengaged. A message is then displayed on the LCD saying "Alarm Disengaged". The program then returns to where it left off.

Arming

To the left is one of the basic sub programs it works by checking to see if there is a high signal on input 6, which means that the button has been pressed on the remote. If there is it checks to see if the variable C is zero, i.e. The alarm is disengaged, if it is zero, the program changes the value to one, i.e. the alarm is engaged. If the value is one, it is changed to zero. This is what controls the alternate action nature of the remote.

Digits

The sub routine to the left was created to utilize the keypad that I have incorporated into my final circuit. It is one of the almost identical sub routines that are used to see if the correct digit has been pressed on the keypad. It scans one row at a time by switching only the corresponding output for that row on and waiting to see if one of the column inputs goes high, if one does it waits to prevent the switch bouncing and assigns a value to a variable F, which is used in the sub routine to display the number pressed. If the number is incorrect, the variable A is incremented by one and the program ends. If the number is correct, then the program ends with no other effect.

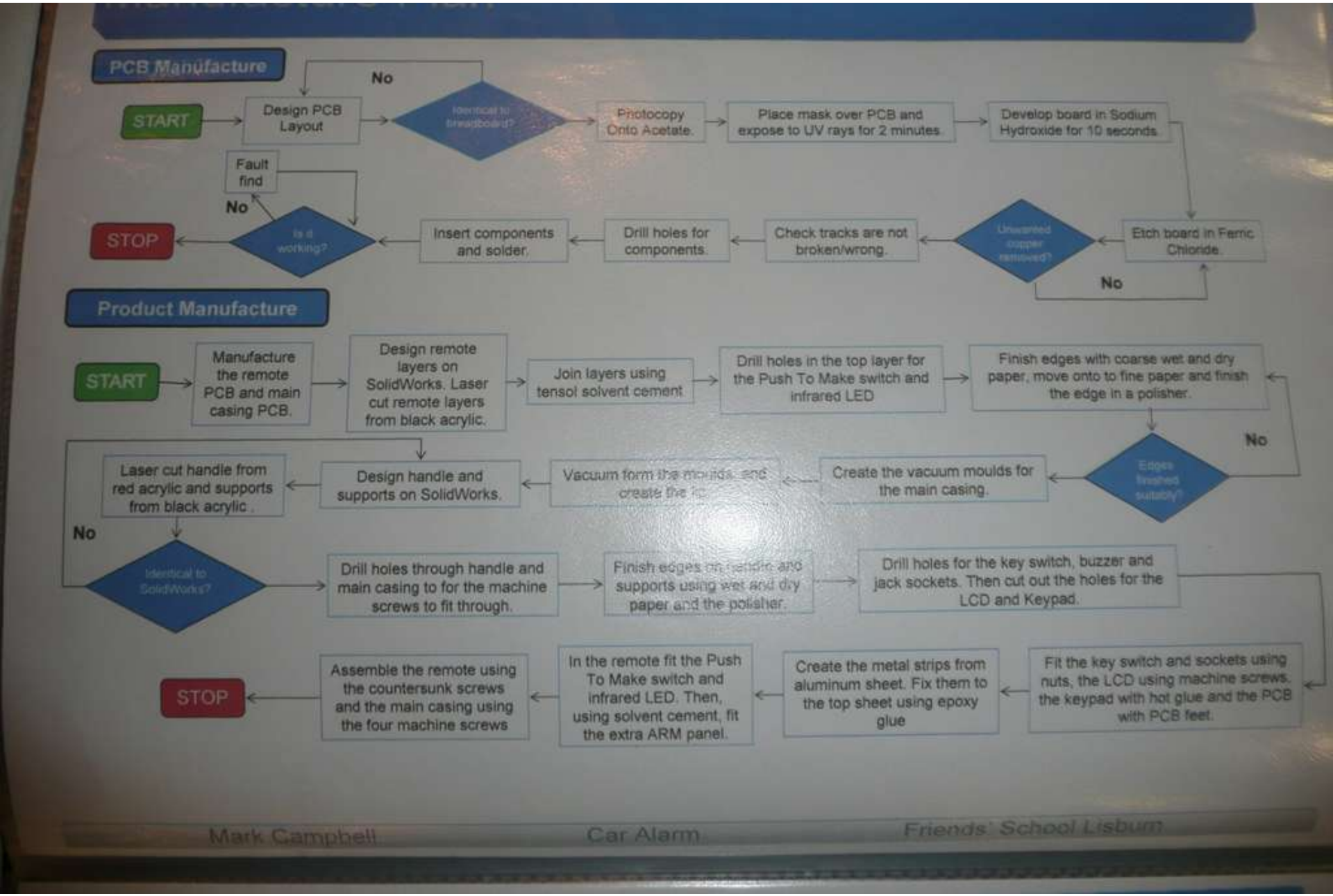
Mark Campbell — Car Alarm — Friends' School Lisburn

Product Development

Mark Campbell

Car Alarm

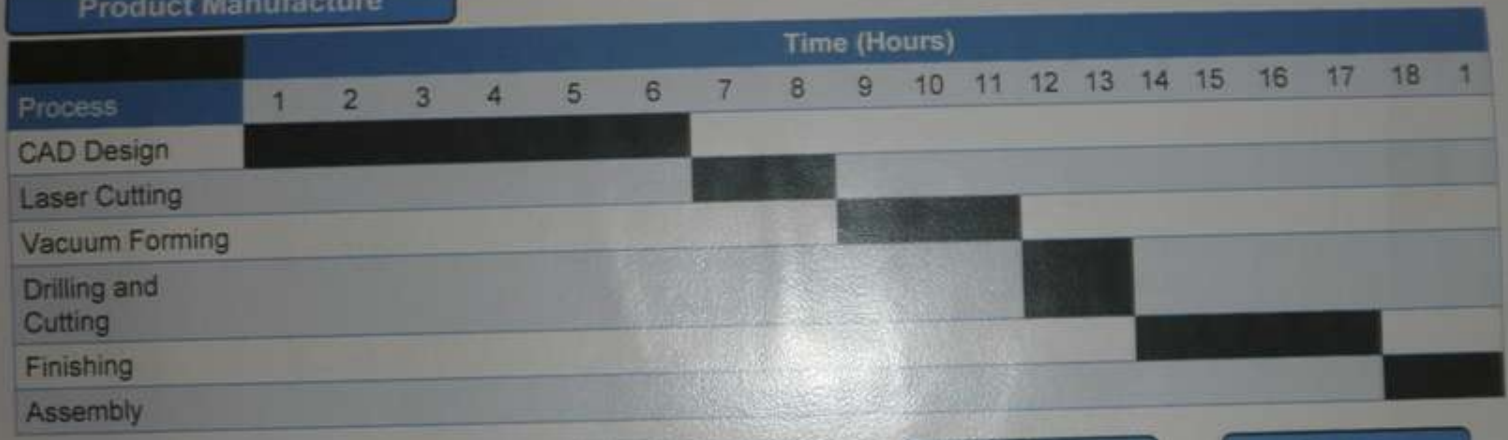
Friends' School Lisburn



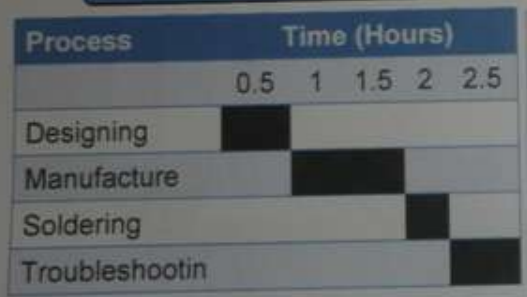
Mark Campbell Car Alarm Friends' School Lisburn

Time and Material Analysis

Product Manufacture



PCB Manufacture



Total Time = 21.5 Hours

Materials

- One 340mm X 340mm sheet of red acrylic
- One 360mm X 240mm sheet of black acrylic
- Two blocks of MDF, both 140mm X 140 mm, 20mm and 30mm respectively
- Two sheets of black thermosetting plastic
- Two strips of aluminum, 120mm X 10mm each
- Two M3 self tapping screws
- Four M4 machine screws and nuts
- Four M5 machine screws and nuts

Equipment

- Laser Cutter
- Pillar Drill
- Wet & Dry Paper
- Tensol Cement
- Polisher
- Vacuum Former
- Epoxy Glue
- Glass Paper

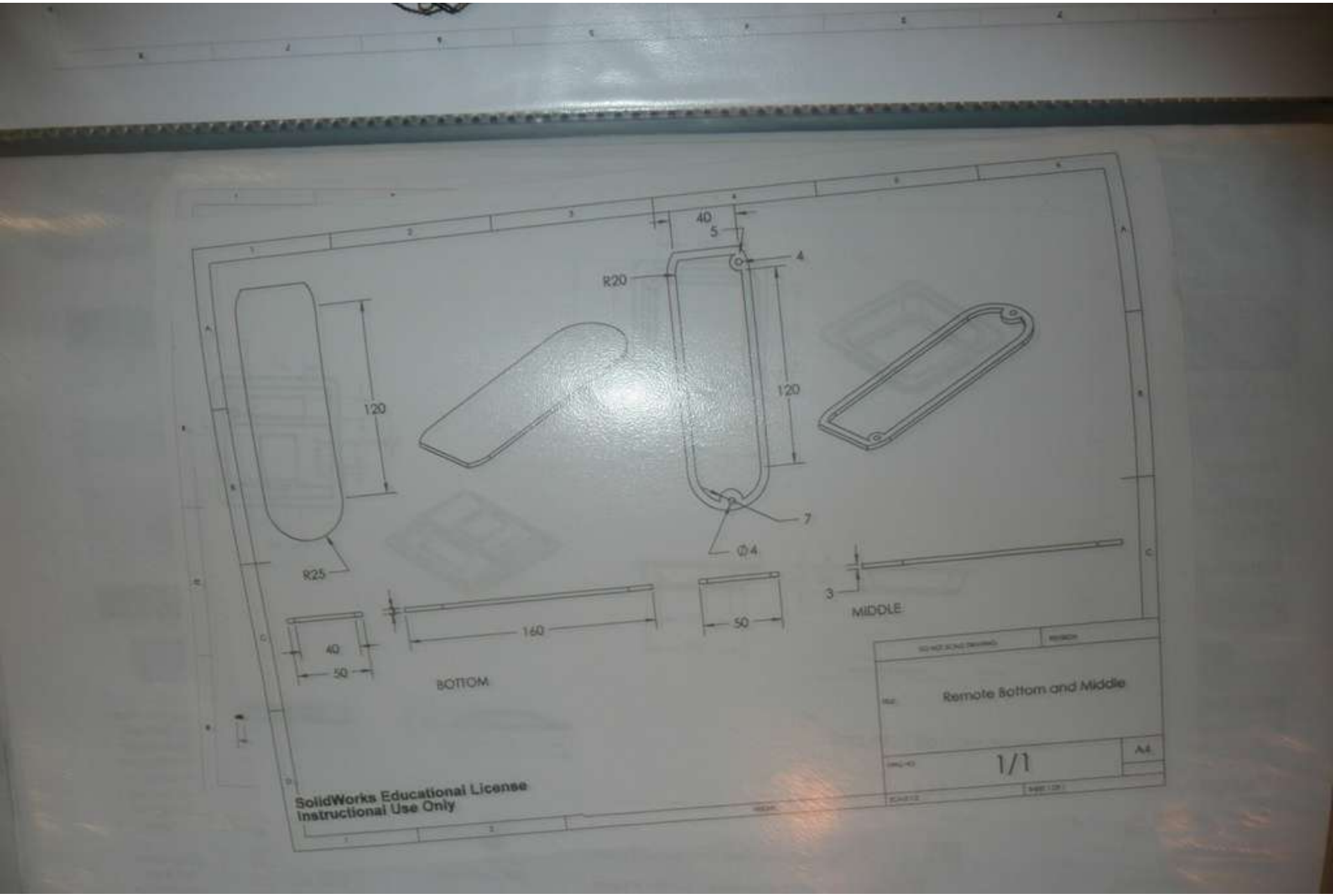
Safety

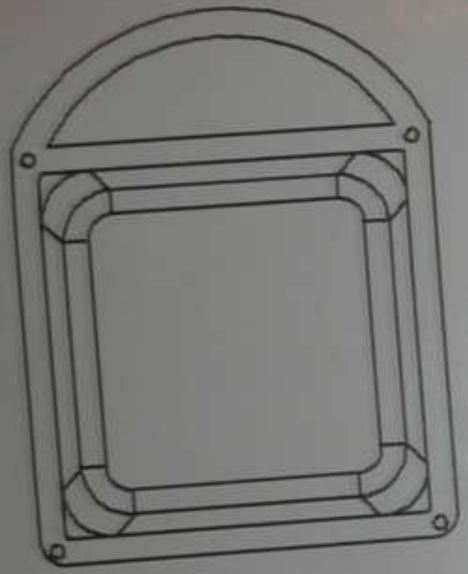
Always wear safety goggles when using any machinery.

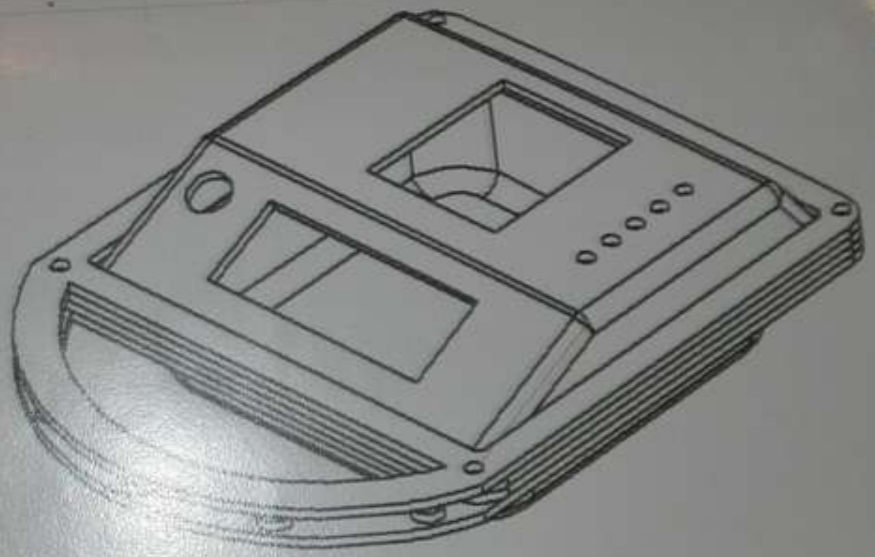
Long hair must be tied back and an apron must be worn to prevent injuries and damage to clothes.

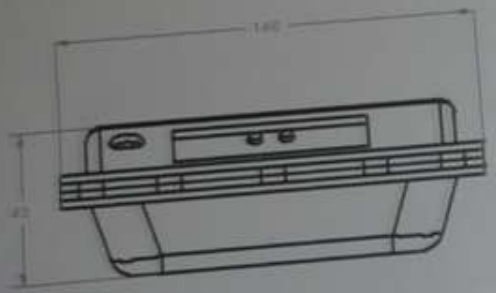
Be careful when using the sodium hydroxide for developing the PCB boards, or when etching the board using ferric chloride as both of these chemicals are harmful and corrosive.

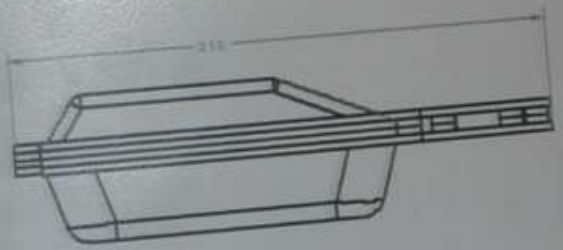
When using the laser cutter, make sure fume extraction has completed before removing material.


40
5
4
R20
120
120
7
Ø4
R25
3
MIDDLE
160
50
40
50
BOTTOM
Remote Bottom and Middle
1/1
A4
SolidWorks Educational License
Instructional Use Only










1/1

Instead of using the originally planned countersunk screws to hold the top layer of the remote to the other layers, I have decided to use self tapping screws as the black acrylic that was being used for the remote was very soft and therefore was very hard to tap accurately without destroying the material. The self tapping screws create their own thread so they were a lot easier to insert into the material, although they do not have the same aesthetic properties as countersunk screws would.

On my final product I have included several panels that cover each component on the top half of the case with the exception of the jack sockets. This is because it was hard to cut out a hole from the vacuum formed material accurately and well enough that it would fit the component exactly. The point of the panels is to better the aesthetics of the case and allow a better fit for the components.

As seen in my SolidWorks drawing, on the remote I planned to place a small panel that said ARM below the Push-To-Make switch. When I started manufacture I decided to make a cut out of the top layer and place the panel in this cut out with a support piece behind it. I feel this makes the remote look more like a professional product and it looks far better when the panel is recessed rather than when it is above the layer.

The original handle supports that I had designed did not work in reality as they were not strong enough. So I designed a new support, although there is a slight gap between top and bottom because the actual gap is four millimeters and the depth of the acrylic is three millimeters but this gap does not affect the integrity of the product and I feel that it looks better than the black cylinder supports.

Instead of having metal strips down the side of the product, which after consideration, made no aesthetic improvement to the product I decided to use small metal circles beside the keypad to add a more professional air to the main casing.

In my final CAD design I decided to have the interior edges of my handle layer filleted by ten millimeters. When I laser cut the handle I found that the radii were too big and therefore prevented the handle from fitting as required. So I reduced the size to two millimeters to get a better fit.

In my plan of manufacture I said I was going to just have a laser cut hole for the IR LED, I then realized that a contrasting front panel would look a lot better where the LED would sit flush with the edge of the panel.

Mark Campbell

Car Alarm

Friends' School

Testing

On completion of my product, I tested it to make sure that it was functioning correctly. I also sought independent appraisal from a security expert.

As shown in the pictures below, the LCD is working correctly and displaying the appropriate characters.


The reed switch connections are inserted correctly and, it is not causing a false alarm


With the case horizontal, the tilt switches are in the neutral position and not causing any false positives for the system.



The keypad is functioning correctly as seen in the video and the two photos below.


The remote works as designed, although the range is fairly poor.


See attached CD for video

I asked a security expert and a fellow of the IET (Institution of Engineering and Technology) Dr George Redpath to assess my product and give me feedback.

What was your first impression of the product?
It is very interesting and aesthetically pleasing and looks like a high quality product. It is also looks quite durable.

Was there any trouble in reading the displays or in using the product?
No, display was very easy to read and made things as to what was happening.

What did you think of the remote size and function?
It is more function driven than form, although it works well.

How comfortable is the main casing to hold?
Yes, its very suitable for its purpose although its range can be a bit temperamental.

Do you have any criticism of the product, or can you suggest any modifications that could be made to the product?
The product would need an instruction manual as it is not very intuitive. There is quite a lag between commands which should be rectified and the handle is not fully supported

Evaluation

Modifications

The remote is not that ergonomically pleasant to hold as the edges do not conform to the shape of someone's hand. To amend this, I would make the bottom of the remote from a vacuum formed mould, so that the bottom edge could be curved to be more comfortable.

When testing my product, I realised that the handle was not confortable to hold, so to correct this fault, I would modify the handle to include finger holds so that it fits better into the shape of the users hand, as shown below.

The range on the IR LED was quite poor so to fix this problem I would either change the resistor for one of a lesser value or increase the power getting to the LED.

In my final product I noticed that the bottom half was wasting a lot of space, so If I was to manufacture this product again, I would create a bottom half which is shallower, thereby making the product even smaller and lighter.

On my product, there is no easy of replacing the battery in the main casing, so if I was to manufacture my product again, I would include I battery compartment, possibly like the one shown.

Instead of having many different component covers, I would laser cut one large piece of red acrylic with slots for each component and then I would line bend the sheet so that it would fit over the top half of the product, increasing its aesthetics.

To allow more flexibility in the product I incorporate a way to harness the battery already in the car, I could a socket for an external power source in the back of the product.

Identification of problem, Need and Specification

Design Brief

The game of air hockey involves two goals for each of the two players. It is played on an air operated table, this causes the disc to float slightly, each player is required to score by hitting the disc into the opponents goal. The game is usually scored to 7 or 9 goals.

I intend to design and make an air hockey scoreboard. This shall be used to keep score of the game accurately. It will not run the risk of being knocked to display an incorrect figure. Individual scores will be displayed. It shall be made safe by making sure that there are no places where fingers could get trapped and securing small parts so that they cannot be swallowed by young children. It will also have none of the internal circuits on display.

The product is aimed at anyone from ages 3 and up. It will incorporate non-toxic materials. It shall be made of hard and shock absorbent materials so that it does not shatter in the event of it being impacted by an air hockey disc.

Problem Identification 1

The game of air hockey requires that a score is kept, usually up to seven or nine. In many cases such as when it is a cheaper model, an air hockey table does not have a method of scoring fitted to it.

Therefore it becomes necessary for the user to employ their own method of scoring, this is often a less accurate method, especially if it involves the players simply trying to remember their scores. This issue is amplified when the product is used by young children who may struggle to score the game to an extent.

Problem Identification 2

When playing air hockey it is often difficult to keep score. Many products on the market consist of a manual counter. These are often knocked unintentionally whilst playing and thus can display the wrong score. On occasions where this goes unnoticed it proves to be an inaccurate method of scoring.

Manual counters can only go up to a limited number which restricts the game to the manual scorer's capability. Manual counters can also break and as they are composed of small parts, they can be difficult to repair and as a result may need replacement should this happen.

Design Specification

Background information: *Air hockey is a game for two competing players trying to score points in the opposing player's goal. When a player scores, it is recorded on a scoreboard, there are manual and electronic devices available for this process.*

Scope of the specification: *This specification covers the requirements for the design, manufacture and eventual disposal of the air hockey scoreboard.*

Competition: *A number of products already exist and are relatively well established, hey are however very expensive.*

Performance: *The display will need to register an input signal in the form of an LDR or push-to-make switch etc. It will need to display the change in score visually. It should be able to accommodate a maximum score of 9.*

Aesthetics appearance and finish: *The scoring system needs to look well-designed, attractive, appealing, fun and easy to use. The appearance will require to be relatively neutral as the device may be required to work in correspondence with different products sporting a range of colour schemes. It would also be appropriate if it were to procure a polished, shiny finish.*

Ergonomics: The inputs to the system must be easy to use if it is in the form of a manual push button. The weight of the system needs to be such that, the item is not too heavy to carry, but also is heavy enough to remain on the side of the table in the event of an impact from an air hockey disc.

Target product cost: Taking into account the materials used and the time spent manufacturing the product, it is likely to cost in the region of £15 -£20.

Materials: There are no pre-determined materials. Those chosen should have good shock absorbance to resist disc impacts. They should be non-toxic as the nature of the product requires that it is handled regularly.

Manufacturing facility: The scoring system is most likely to be made and assembled in the school's technology department workshop.

Maintenance: The product is to be made of durable materials, however since it is an electronic system it's battery life will not be everlasting, these will need occasional replacement.

Safety: The main issues relate to younger users, there should be no small parts which could be swallowed, there should be no sharp edges, the power supply should be a low voltage so there is a negligible risk of a shock. The materials should be shatter resistant so that if a disc causes a significant impact, pieces should not chip off.

Testing: The product will need to be tested in relation to all matters covered by this specification. No standard procedures exist and so tests will need to be devised.

Disposal: The product is expected to have a long life in service, but in the event of it breaking or being replaced, it shall be designed so that it can be disassembled, so that parts can be recycled or reused when it comes to the end of its useful life. Polymer materials should be clearly labelled so that their type can be identified.

Existing Solutions

Function: This is a simple manual counter which is operated by hand, whenever a goal is scored, a number has to be slid across. This is limited to a total of ten recordable goals per game.

Aesthetics: The aesthetics appeal of this product is fairly basic and incorporates fairly dull matt colours of grey and black. The product looks relatively simple with an average texture and finish.

Ergonomics: The product incorporates a number of ergonomic features. Anthroponemtics have been utilized in the construction of the individual numbers as they each have an indented groove to fit the finger for when they are being slid across. It can also be drawn to attention that it is not too high up from the table meaning that it does not interfere with game play.

Fitness for purpose: In a generalised sense, this product fits its job role very efficiently and does what it is simply required to do. A few issues with the product, however include that it has a limit to what it can be scored to and the numbers could slip if knocked while playing.

Function: This electronic counter is a more expensive model than the one above and it has more features. It has the capability to score the game up to 9. It does not require manual operation once playing due to automatic sensors located in the goals. When a player wins a buzzer is activated.

Aesthetics: The device contains colours to match the colour scheme of the average air hockey table to which it is fitted so that it is not a stark contrast. It has the appearance of sturdiness and shock resistance.

Ergonomics: The seven segment displays that this particular product incorporates give off their own light so they are visible if playing in a darker environment. The device has considerable ease of use, the product is self activated when the table turns on and keeps score without the need for manual inputs.

Fitness for purpose: This products suits its purpose well and records the score of the game accurately, however it has a limited number of features and does not offer the ability to play for a timed period.

Function: This scoring system is manufactured specifically for the air hockey table pictured. It has the ability to count up to nine. Manual operation is not required once activated.

Aesthetics: This products aesthetic appearance including its colour scheme is most suited to an arcade environment, as the device is designed for the air hockey table in question which is to be a paying air hockey table requiring players to insert

Ergonomics: This product has good ease of use as it does any manual inputs once game play begins. The score display level with the average person's line of vision showing a of anthropometrics.

Fitness for purpose: This fits the purpose well as it can record score without the requirement for manual interaction. The however, limited with only the capability to record the score are no features for timing the game.

Function: This is an expensive option, which offers many features including a down counting timer which offers a range of time periods. It records individual scores and lights indicate when there is a winner and which player wins.

Aesthetics: The aesthetic appeal of this product is average, the casing incorporates a matt finish making it look a little dull. This is partially compensated for by all of the striking light features located in the 7 segment counters and the winner indication lights.

Ergonomics: Made of durable materials with shock absorbent properties so that it is protected to an extent in the event of it being impacted by a disc. It features the use of anthroponemtics as it is hung above the table at the average person's eye level.

Fitness for purpose: There are numerous features which make this appropriate for its purpose and it does not require manual operation as it is activated by sensors in the goal. It also has a higher scoring capacity meaning that one game can last longer.

Function: This product is built into this specific air hockey table and so therefore it is not available for use with other tables. It incorporates two individual counters for both players and also has a timer which can be set to the specified time. The score inputs are activated in each player's goal.

Aesthetics: This product performs relatively well aesthetically as it uses the same colour scheme and textures that features on the rest of the table. It also has a professional appearance.

Ergonomics: The device is made of shock resistant materials, which is necessary as it is located in an area where it is at risk of being impacted by discs leaving the table. It is however at a difficult angle for players to see easily and younger players in particular could struggle.

Fitness for purpose: The device fulfils its purpose very well with all of the necessary functions available to players in a professionally designed format, although its display angle could be improved.

Function: Score inputs are found in each player's goal and are displayed on the 2 seven-segment displays for each player, the scores count continuously until reset so it is up to the individual players to decide on the winning score.

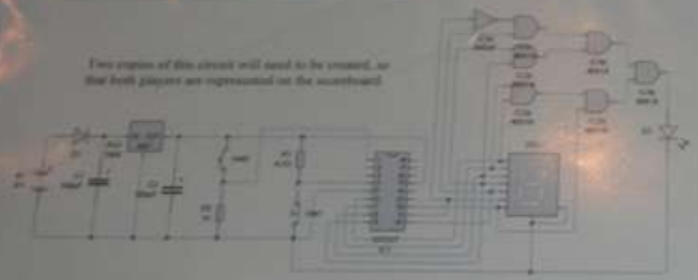
Aesthetics: This product performs very highly aesthetically with an attractive covering of glass with red LEDs to enhance this. It is made in an attractive shape and would look well in most environments.

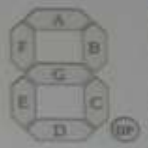
Ergonomics: This product is very easy to use with a simple method of operation, it counts continuously until reset meaning the players have the ability to choose how long they want to play for.

Fitness for purpose: This product fits its purpose well. It is a flashy product and has a limited amount of features and does not offer the opportunity for the game to be timed. It can however count up to 99 meaning that it is more versatile than many other products.

Initial circuit idea 1

Two copies of this circuit will need to be created, so that both players are represented on the scoreboard





Logic arrangement

The logic arrangement incorporated into the circuit is used for the LED to be lit only when the display registers a nine, the NOT gate is required as the number 8 also uses the same segments of the display with the addition of the E. segment. The Combination of AND gates means that all of the necessary segments are illuminated for the LED to become lit.

16F627 pin layout

Input: *The input for this circuit is a micro switch (labelled SW2) in parallel with a 1K resistor this is located in each player's goal and is triggered each time a player scores a goal and provides a digital input pulse into the 16F627.*

Control: *The control of the circuit is the PIC 16F627 which upon receiving the digital pulse input from the micro switch it sends a signal out through the appropriate output pins. It is connected to the positive rail by pin 15 and to the negative by pin 5.*

Outputs: *The seven segment display is operated to display suitable digits depending on the output pulses it receives from the 16F627. It is a common cathode display meaning all of the negative legs of the LEDs (light emitting diodes) are connected to the negative rail. There is also an LED output which is activated when a player reaches 9.*

Feedback: *The feedback is in the form of the reset switch which changes the seven [illegible] display back to zero. It is operated by a push to break switch (labelled SW1) in [illegible] resistor. This is connected to the reset pin (pin 4) of the PIC 16F627.*

7805 Voltage regulator

A PIC functions at a supply voltage of 5V-6V, any higher and the chip becomes damaged. The input to this concept circuit is in the form of a 9V battery. This is too high for the PIC I am using (16F627). So therefore I have put in the 7805 voltage regulator circuit so that the supply voltage can be reduced from 9V to 6V. Below is a quick experiment that I did to ensure that this system works properly. Firstly, I constructed the schematic drawing using livewire. To check that I had constructed the system properly, I then wired it up onto a Protoboard and tested it with a multimeter. I then converted it to PCB using PCB wizard, from this I constructed the PCB and tested it again with the multimeter.

PIC programming Flowchart – [illegible]

Using PIC logicator 1.6, I created the flow diagram below to operate the PIC, It contains two decision boxes "switch pressed" and "switch unpressed" acting as the input to decide whether the push to make input switch has been activated. Once it has been activated the increment box "INC A" adds one to the variable "A" representing the count on the seven segment display . Each time the switch has been recognised, the macro named "display" will be activated where it is decided what the variable "A" is and the seven segment display is sent an output to show the current figure.

Initial Product Idea 1

The writing "WINNER" is used to identify the box as the device which displays the winning player. The writing can be created by using the CNC router machine to cut the word into the wooden mould for the casing to be formed over

Casing: The casing for the circuitry could be created by using a vacuum former to form high impact polystyrene over a wooden mould, this will form a split mould, which is hollow so that the circuit can be contained.

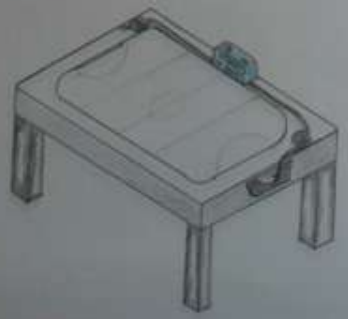
Reset switches: Whenever the LEDs are lit or the game is over, the two push to break switches can be activated to reset each counter and switch the LEDs that are on to the off position.

LED: When the counter reaches nine, an LED is lit to signal which player has won.

Seven segment Display: these are used to show each players score, they will increment up whenever the input is activated.

Micro switch: This is located in each player's goal and when activated by the disc, the other player's counter is incremented to register their point. The micro switch's position in the goal is presented orthographically below:

ON/OFF switch: [illegible] single throw switch is [illegible] to enable the potential for the circuit to be switched on and off without the requirement of inserting and removing the battery each time a change of state is needed.



The illustration (left) drawn in isometric shows how the device will be arranged on an air hockey table. The micro switches are located in each player's goal, to be triggered when the disc impacts them. This will result in the incrementing of the appropriate counter, the counters are set at each player's goal and it display's their score. The part of the device which displays the winner is located at the side of the table in the centre where it is clearly visible to both players.

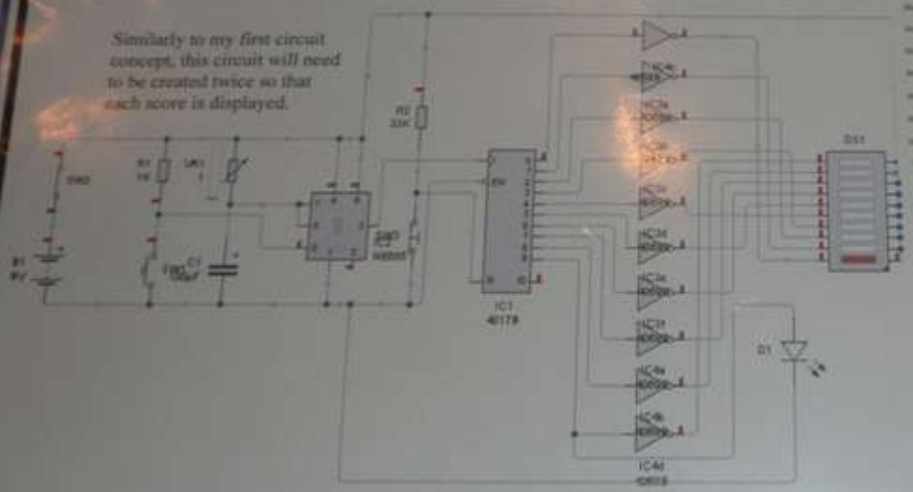
Plan

Side

Front

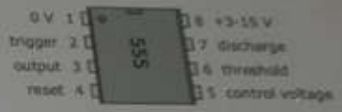
Initial circuit idea 2

Similarly to my first circuit concept, this circuit will need to be created twice so that each score is displayed.



4017 Pin Configuration

555IC Pin Configuration



Logic arrangement

When the 4017, which I am using to drive the bar graph display activates the output, it causes it to light all segments except one which is the segment representing the current score, to remedy this, I have incorporated NOT logic gates to invert the outputs to the bar graph display causing it to do the opposite and thus the score can now be displayed by the illuminated segment. The display counts from bottom to top which is why the NOT logic gates have been put in with output zero connected to the bottom segment etc.

The Bar Graph Display

A bar graph display consists of 10 LEDs, packaged in a 20 pin DIL IC. The supply voltage is usually in the range of 3V to 20V. If an analogue signal is fed into the display driver the number of LEDs lit increases as the analogue signal voltage increases.
If the analogue input signal voltage is 0V then no LEDs are on. It is capable of showing variations in analogue quantities like temperature. In this case, the 4017B chip is increasing the voltage in equal stages.

Input: The input for this circuit is a push-to-make switch (labelled SW1) in parallel with a 1K resistor. One of these is located on each side of the board and is triggered manually when each player scores a goal.

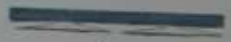
Control: The control of this circuit involves the 555IC timer which upon receiving the input pulse into pin 2 (Trigger) sends an output pulse to the 4017B chip which each time upon receiving a pulse it sends a different output in sequence from zero to nine.

Outputs: The output for this circuit is the bar graph display, each segment represents a different score, as the bar graph display receives a digital pulse, originally generated by the PTM switch, it illuminates a different segment, going from the bottom of the display to the top. It is a common anode display meaning that all positive legs of the LEDs are connected to the positive voltage rail. There is also an LED which lights when the counter reaches ten.

Feedback: The feedback is in the form of the reset switch which, upon activation makes the bar graph display return to display 0.

Initial Product Idea 2

Input switches: These push-to-make switches are manually triggered by players when they score, this is registered on the bar graph display as it sends a digital pulse through the system.



The device could have the capability to be fastened to the air hockey table via suction cups located underneath.

The clip attached to the back of the scoreboard gives it the capability to be hung on a wall.

On/Off switch: this SPST (Single Pole, Single Throw) switch can be activated to either turn the device on or off.

Front

Writing: the writing on the device which reads "Score" and "Reset" could be created using a CNC milling machine to carve the writing into the wooden mould which will indent the HIP during vacuum forming.

Bar Graph display: This is used for the counting in this case. As each player scores and triggers the push-to-make switches, these will display an increase in score, each time a digital pulse arrives, a different segment is illuminated, this works it's way up to the top of the display, once it reaches the segment representing ten, that player has won.

Casing: the casing for this unit could be produced by a blue high impact polystyrene split mould created through the process of vacuum forming.

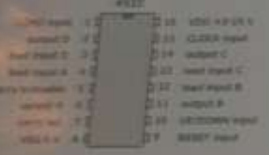
LED (Light emitting diode): One of these will light when its corresponding Bar graph display reaches 10, this acts as a method my which to display the winner.

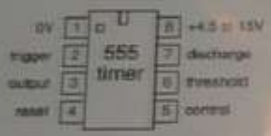
Side

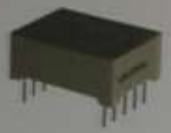
Plan

Reset switch: This takes the form of a push to break (PTB) switch and when activated, it resets the counting bar graph displays to the null position so that a new game can begin, it will also switch off any LEDs which may be lit.

Initial circuit idea 3







Overall Operation:

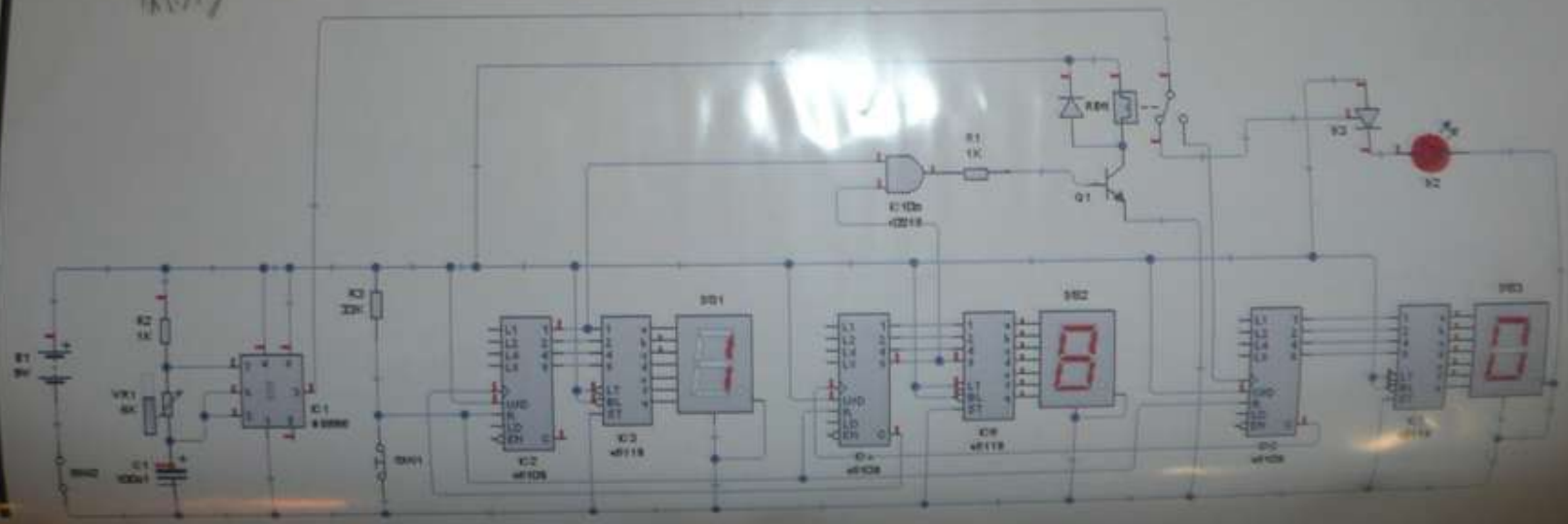
How this circuit essentially operates is that once it is activated the timer will count up to 180 seconds (3 minutes) once this happens the time stops at 180 and an output in the form of an LED comes on to show time is up.

The overall operation of this circuit begins with the **input** which is in the form of a 555 timer This is used to send a digital pulse to create a clock timer. The pulse frequency is controlled by the astable arrangement in which the 100nanoro Farad electrolytic capacitor, the 1K resistor and the variable resistor set to 6K, these values create a pulse equal to that of a clock. The power can be completely switched on or off by the SPST switch labelled "SW2."

The processes involved in sending the input pulses to the output consist of a 4510B BCD (Binary coded decimal) chip receiving an input pulse from the 555. The U/D pin (Up/Down) is tied up to the positive rail so that the counter counts up, the four outputs 1, 2, 4, 8 pulse into the 4511B chip which is a binary decoder, as the 4 inputs send signals in, the chip converts it to signals which will drive a seven segment display. The 4510B chip has a pin labelled C (carry) this is used to carry on to the next display so that it will count up numerically.

The **outputs** consist of the seven segment displays which show the time, they count up to 180. The output pins of the 4510B's can be tied up for 180, when the display on the far left displays 1, the output from the connecting 4510B will be output pin 1 only and the middle display will have output pin 4 only when displaying 8. So the legs representing 1 and 8 can be tied up into the AND gate, so that once they are both at the predetermined state, a positive pulse will be allowed through the AND gate and into the transistor which switches on and drives the SPDT relay which has a diode to control the flow of current so that EMF from the relay coil doesn't travel back and damage the transistor. The relay will then switch state and will switch on the LED, and it is held on by the thyristor until reset, this will mean that the counter will stop at 180.

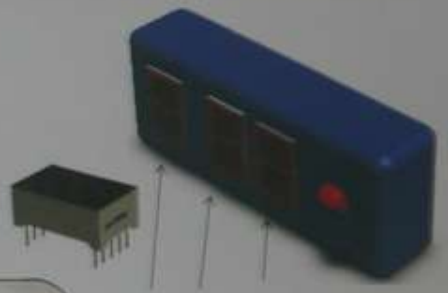
The **feedback** for the circuit consists of the PTB (push to break) switch labelled "SW1," once this is activated, the counters will reset to display zero and the LED will switch off.

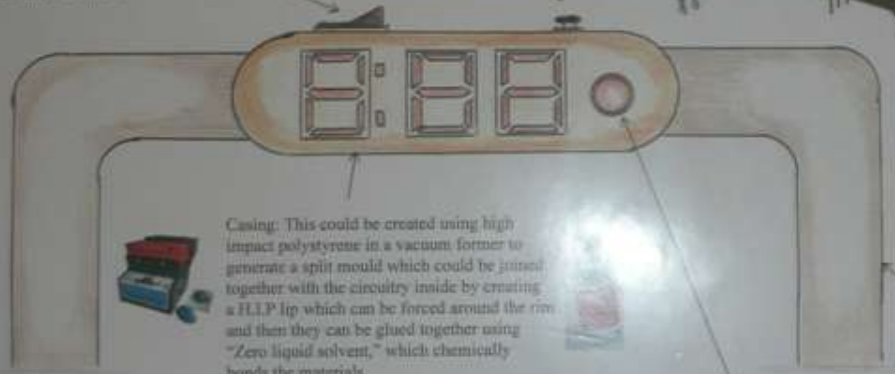


Initial Product Idea 3

On/Off switch: This SPST (Single pole, single throw) switch enables the system to be switched on or off without the requirement to take out or put in the battery each time. Activating this switch also activates the timer.

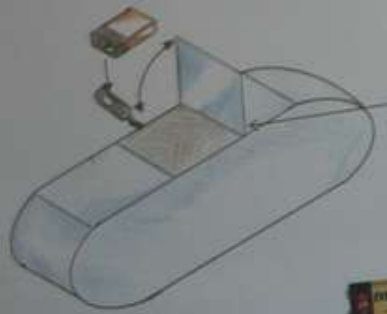
Reset Switch: The push-to-break switch is used to reset the counter and switch off the LED if required, by doing this, the counter can then begin counting the three minutes again from zero





Seven-segment displays: These are the output method I have selected to display the time on the counter which enables player's to time their game, when each segment receives a digital "ON" pulse, they will illuminate thus displaying the appropriate number.

Casing: This could be created using high impact polystyrene in a vacuum former to generate a split mould which could be joined together with the circuitry inside by creating a H.I.P lip which can be forced around the rim and then they can be glued together using "Zero liquid solvent," which chemically bonds the materials.



The Device incorporates the ability to open a compartment on the top so that the battery clip can be accessed for the changing of batteries, in this way it does not require the device to be dismantled for the battery to be replaced.

LED: This simply lights when the timer reaches 180 seconds to signal to the players that the game or round is over.

The Device has the capability for being mounted across the centre of the air hockey table on a bar which could be created with aluminium bent in the vice. This would mean that the display is viewable without the requirement of turning the head to the side and becoming distracted from game play, this would mean that the output would need to be connected up twice so that both players have the opportunity to view the time remaining. Thus the product would have a second set of seven segment displays and corresponding LED on its reverse side.

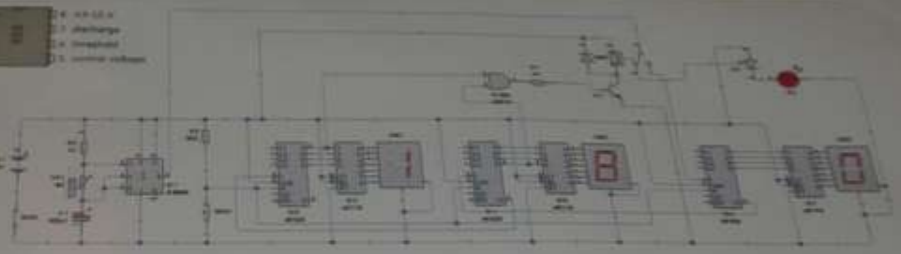
Circuit Development

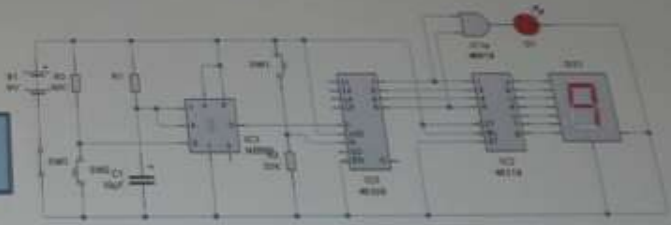
The circuit to be developed is presented here on a breadboard schematic. It involves a timing circuit and a counting circuit.

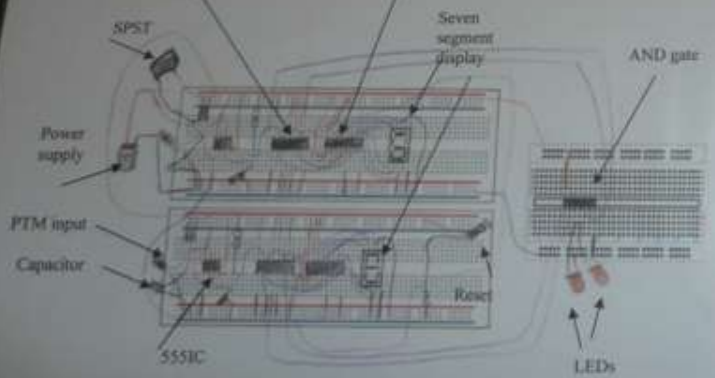
Timer: This consists of an Astable timer which generates a clock pulse, this has required the following components to accommodate the correct time interval for the digital pulse: 1K resistor, 100microFarad capacitor and a 6K resistor. The digital pulse goes into the 4518B ICbp and creates a binary count, which is carried into the 4511 chip which is a binary decoder and it converts it to a signal which can be registered on the seven segment display. When the counter displays 180 (3 minutes) the AND gate will send through a pulse to the LED signalling that 3 minutes has passed.

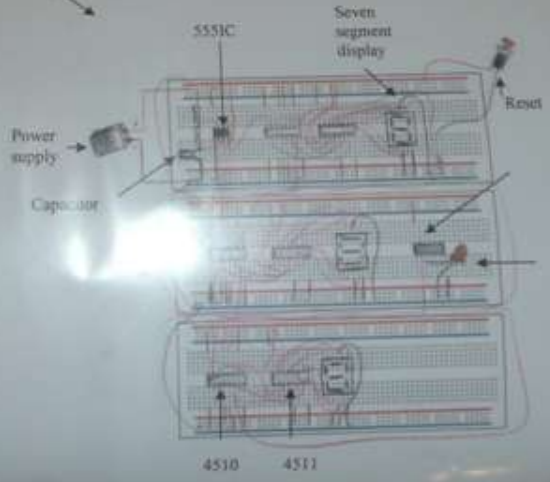
Counter: This consists of a monostable input which is activated by a PTM switch which when pressed sends a signal to increment the seven segment display. The pins for 1 and 2 are tied up into the AND gate so that when the display reads nine, these outputs will both be on and an LED will light up signalling the winner, there will be two of these, one for each player.

After establishing working circuitry on breadboard, a plan was then drawn up for constructing a breadboard.



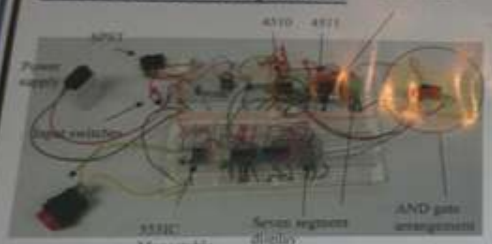


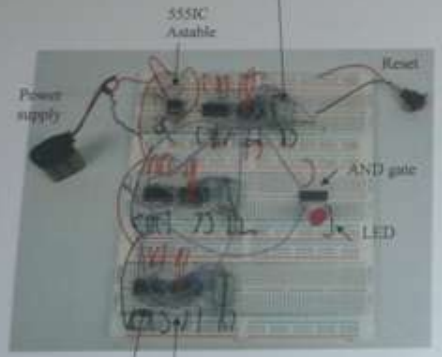




Pin layout for the specific 7 segment being used

Circuit Development





Protoboard construction:

After planning out the breadboard, its construction could then occur. The monostable (pictured at the top) has now been created to incorporate both resistors for each astable, during its building it was discovered that it required a few modifications from the original plan:

•Upon pushing the reset button, the seven segment would count more than one increment, to remedy this, a capacitor and resistor were placed in parallel to de-bounce the signal, thus sending only one pulse.

•It was also found that the longer Protoboards necessitated a wire at the positive and negative rails as the way they were constructed was that they were composed of two interconnected smaller breadboards.

The datalite (pictured below) also required some modification in order for it to function:

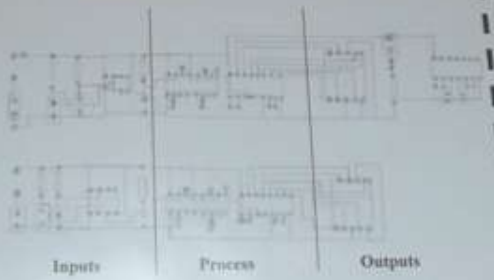
•Likewise with the monostable, the breadboard had to be connected in the middle due to the nature of its construction.

•To create the correct timing, it was also realised that it was necessary to replace the 6K resistor with a 6.8K resistor

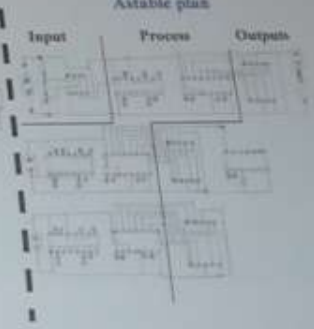
•It also became apparent that if the circuit was to halt the game with the relay it would restrict the length of time for which players could play for, so the relay system was removed so that it is still indicated when 3 minutes has passed but also can continue counting so that games can be longer

Photo showing AND gate arrangement working.

Monostable Plan



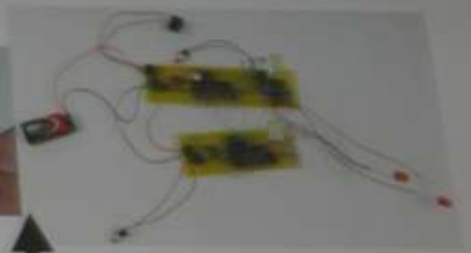
Astable plan



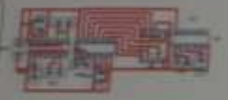
After designing and constructing the working Protoboard circuitry, the PCB layout could the be planned. It required the routing of tracks in surrounding areas when combining the BCD counter, decoder and 7-segment display, to achieve [illegible] terminated routes through components, and some jump wires were needed between the 4510's and 4511's. These were initially facilitated by incorporating pads onto the copper tracks, it was also needed for carrying the power supply to the whole circuit.

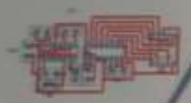
Circuit Development

Printed on Acetate to be made into PCB

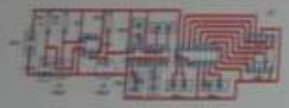


Astable Timer





Monostable Counter

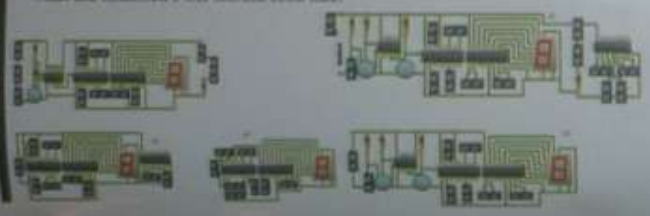


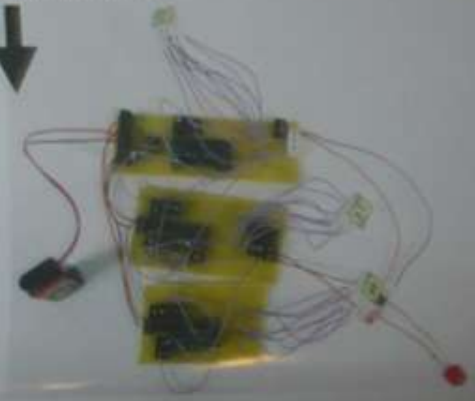
Monostable: Pictured above is the operational Monostable counting circuit used for scoring the game. Then photo on the left illustrates that when each display reaches 9, their corresponding LED activates. The photo on the right shows the monostable in its entirety with the PTM input through the 555IC timer into the process stage consisting of the 4510 and 4511 chips, the outputs consist of the seven segment displays presenting the score and the LEDs indicating that a score of 9 has been reached by a player. The feedback is in the form of a reset switch.

Astable: Below is the functioning Astable timer for timing each game. On the left is a photo showing the soldered side of the PCB and the copper track. The right hand photo shows the timer in the process of counting. With the input being the 555IC Astable which provides a clock pulse. The process, similarly to the monostable is the 4510 and 4510 chips. The outputs consist of the seven segment displays which show the time of the game, when it reaches 180 seconds (3 minutes) the LED lights up indicating that that specified amount of time has passed.

When finalising the PCB, it was necessary to implement a number of modifications in order for it to be successful, the pads which were being used for jump wires were replaced with terminal blocks so that it created a stronger hold and if a wire needs replaced, soldering does not have to be removed. Terminal blocks were also applied for LEDs and switches so that they were not restricted with their position in the final device.

Real world view: This gives some indication of what the finalised PCB should look like.





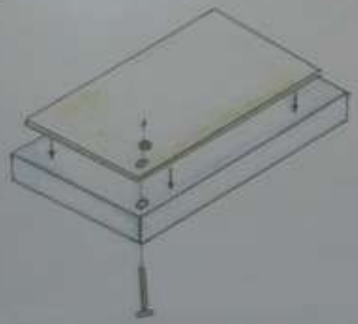
Product Development

To create the product it is necessary to consider and potentially incorporate some of the following ideas.
Firstly, the process of vacuum forming could be used to create an appropriate housing for the circuitry. This operates by heating up a sheet of plastic such as High Impact Polystyrene until it softens and then forcing a wooden mould into it and then creating a vacuum by sucking all the air out and thus creating a split mould.

When creating a split mould it also becomes essential to engineer a method by which it can be joined together. The first consideration here is by simply taping the two halves together, it is however not a very sturdy method of joining and would possibly fare better if used in conjunction with other methods.

Another method of joining the two halves of the split mould together could be to create a lip to go between them to hold them in position. This could be generated by cutting a thin strip of high impact polystyrene on the guillotine and then bending it round the inside rim of one of the sides of the split mould. To aid the bending of the strip, a heat gun could be used to soften the plastic so that it is less rigid and less likely to damage the mould. It is then held in position with pegs whilst it is glued with liquid solvent cement which bonds the material together. When dried, the two halves can be fitted together and the rim will hold them in place.

The circuitry could be mounted on plastic foam so as to protect the casing of the device so that it does not get scratches from sharp trimmed wires underneath on the solder-side of the PCB. It could be fastened by drilling a hole through both the circuit board and the foam and securing them with a nut and bolt.

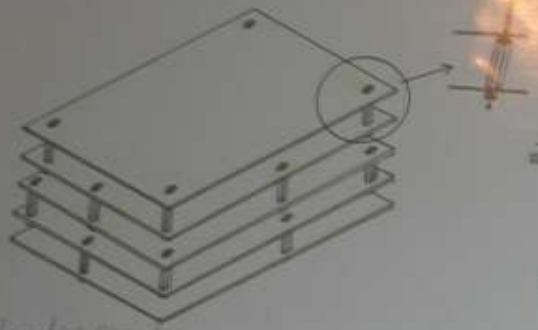


Inevitably, the device will be required to contain circuitry. One consideration for this is the method for accessing the batteries. In this hand-drawn sketch, it is illustrated the possibility of incorporating brackets on the innermost section of the mould, and batteries can simply be held there.

To make the batteries more accessible, it could also be possible to drill hole in the side of the mould and have the battery clips fed out meaning that they can be easily accessed from the outside without the necessity of opening up the mould to reach them.

Product Development

When putting the circuitry inside of the casing it may be necessary to stack it to make it neater. This can be achieved by incorporating spacers in between each PCB. Holes need to be drilled and a nut and bolt are fastened either side of alternate circuit boards.



There are 5 seven-segment displays that need to be incorporated and this could be achieved by cutting appropriately sized holes in the device using a Stanley knife and hand file. The seven segment displays could then be glues into position using araldite glue.

Incorporation of concept ideas

The next stage is to establish what the product is desired to eventually look like, this will involve drawing ideas from the previous concept section and generating further modification in order to suit the ultimate product criteria.

Concept 1

It was decided that the ideas that could be drawn from concept 1 could be that the idea of being able to count the score using seven segment displays is a very effective method. Also, the idea that an LED activates upon one or more of the players reaching the target of nine shall be brought forward into further development. The idea of a split mould is also used here and as discussed previously would be a very appropriate method of creating the circuit's housing.

Concept 2

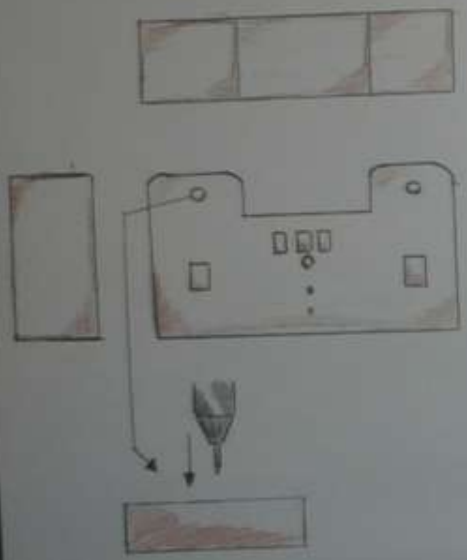
Concept two is the initial idea which reflects best the appearance that is being strived to achieve. As this shape is arguably the best aesthetically and thus it is the general shape that shall be carried forward. Also, its method of counting is also to be incorporated, the two PTM (Push-To-Make) buttons located on each of the individual protruding sections from the top of the product give the opportunity to manually trigger the scoring as when incorporating the capability for automatic scoring, the disc can sometimes bounce or by some method trigger the input switch more than one in a single goal. However, this method of displaying the score has been rejected as the seven-segment-displays, it is clear, are more appropriate for this job as they can simply be read off rather than having to count bars.

Concept 3

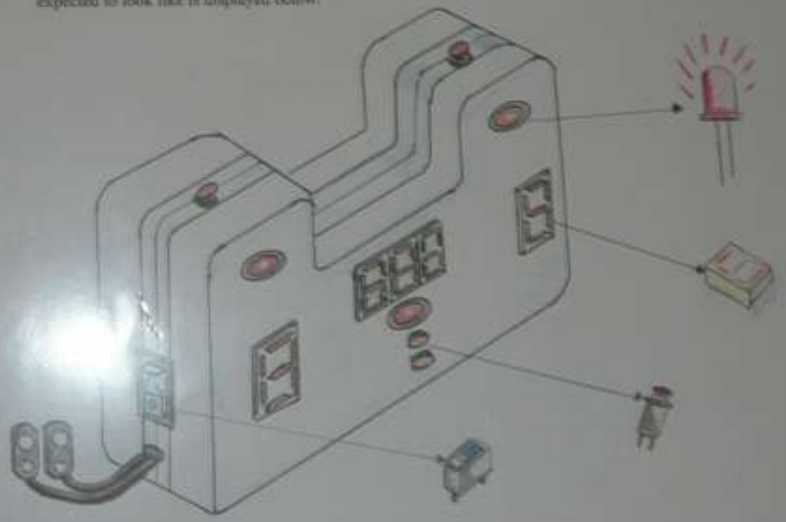
The main idea drawn from concept 3 is the ability to time the game and light an LED whenever the game has lasted 180 seconds (3 minutes). This gives the overall product greater depth and enables it to carry out more functions as an air hockey scoreboard.

Product Development

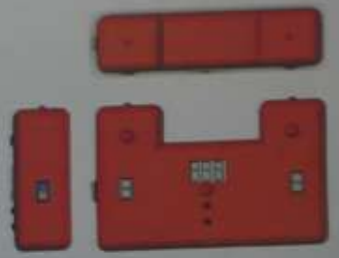
The mould for the vacuum forming will need to incorporate indents to enable the compatibility of the circuitry with the housing. The holes for the seven segment displays will need to be cut out using a milling machine to a depth of about 5mm. The holes for the switches and LEDs can be drilled using a pillar drill to the appropriate diameter. An orthographic representation of what the mould could potential look like is displayed below.



Once the housing has been vacuum formed and the holes for components cut out and the circuit fastened into position it can then be fastened together. The methods chosen for connecting it together here are to combine both the method of creating a lip to go around the whole edge and also some colour coded insulating tape to neaten it up and to further hold it in position. An isometric illustration of what at this stage the projected final product is expected to look like is displayed below.



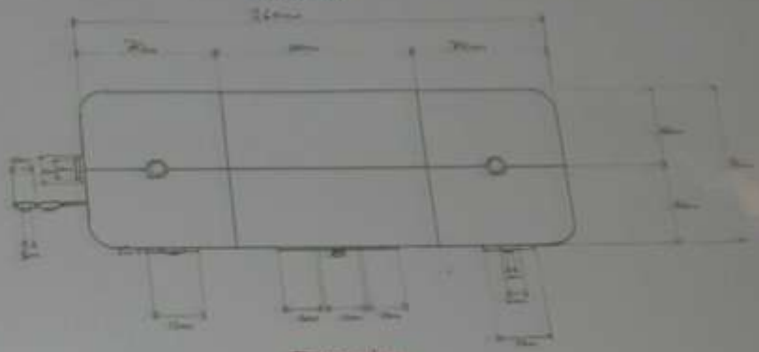
The positioning of the seven-segment-displays having been decided upon and also the location of the rest of the components with the chosen method of battery access being to have a small hole drilled in the side of the product to enable battery clip access. Next, a final drawing can then be created so that it can the plans for the construction are more efficiently run as there will be a guideline by which can be referred back to to get inspiration as to what it is expected to look like. It is presented here in orthographic form using computer aided design software.



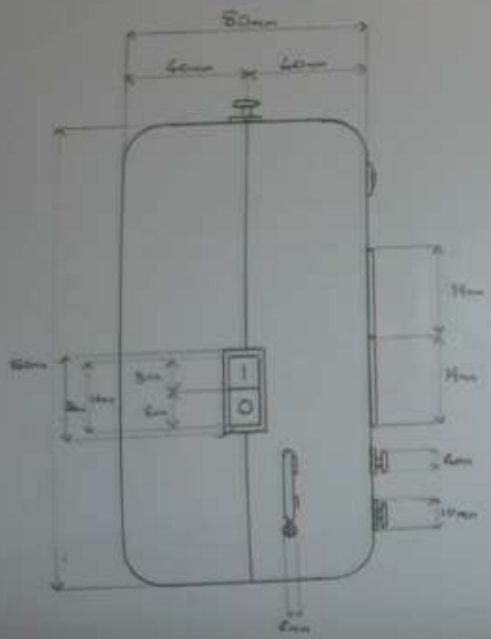
Working Drawing

This is a working drawing of what at this stage the final product is expected to look like. It is presented in orthographic illustrating the plan, side and front views. It incorporates measurements so that the eventual product can be planned for and constructed efficiently.

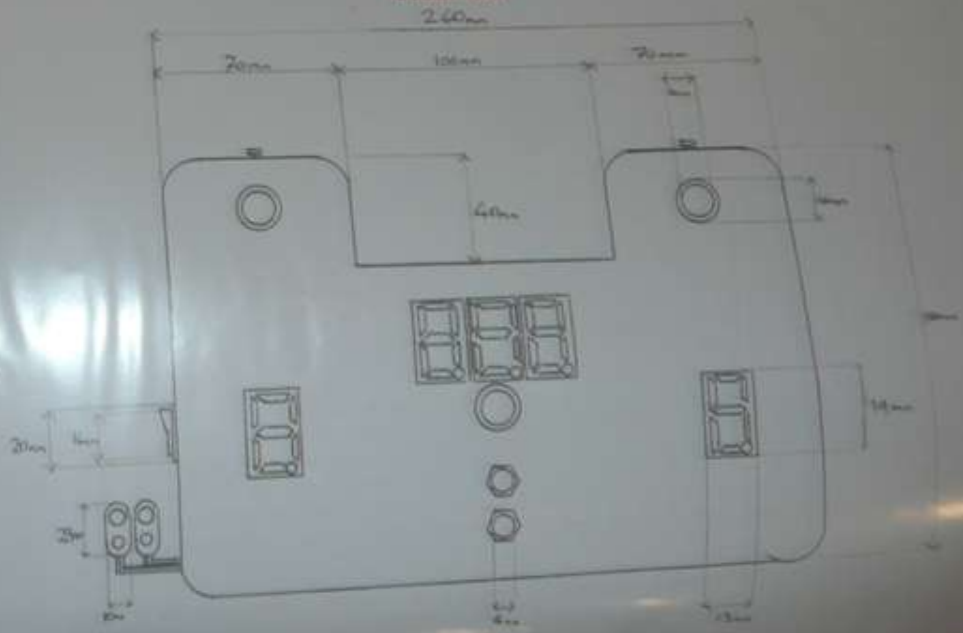
Plan view



Side view



Front view



Presentation Drawing

Solidworks

This drawing has been produced using the CAD (Computer Aided Design) program "Solidworks." It is presented in isometric view angled at 30°. It provides an illustration projecting what the final product will ultimately look like so that there is a good idea of what is being worked towards during construction.

Materials:
The products main body can be created using a MDF mould to create a (vacuum forming) High impact polystyrene split mould. The lip to connect the split mould can also be created using a strip of High impact polystyrene. The circuitry incorporates Silicon PCBs potentially connected with mild steel sockets. The components will be fitted to the PCB with solder.

Plan of Manufacture

Circuitry Plan

1. The circuit construction initiates by generating a working schematic of the circuitry on livewire.
2. After a fully operational circuit has been created, it is then necessary to make a plan for building the circuit on breadboard. This involves identifying the destination of components and will require the usage of chip data.
3. The next stage is creating a physical working circuit on a breadboard (breadboard). This requires that the plan is followed and that the appropriate components are obtained and incorporated.
4. Once the prototboard is functioning properly, it is then important to create a plan for the PCB (printed circuit board) layout. This means that the next stage can be carried out with greater efficiency.
5. Following the creation of a plan, the actual PCB layout can be constructed using PCB wizard, it is important to make sure that tracks are not touching and that pad size is sufficient. Ideally there should be as few jump wires as possible.
6. Once a confirmed PCB layout has been established, it can be printed out onto acetate. It must be printed twice onto separate acetate sheets and fastened together due to the nature of UV light.
7. After the acetate has been created, it then moves onto the PCB production stage where the PCB layout is created on a silicon board and a copper track is generated.
8. Before the circuit can proceed any further a chemical such as "Electro-Brite Resist Stripper RS-801-Q" should be used to remove material from the copper track which collects during the production stage, these can cause reduced conduction. It can be applied by adding a few drops to some paper and then wiping the circuit board.
9. The PCB must now be drilled, each pad needs to be drilled to 0.8mm and the terminal block pads should be drilled to 1.2mm.
10. Prior to locating the components on the PCB, they must first be prepared. All of the seven-segment-displays, switches and LEDs must be connected to multi-core wires by soldering. They must the have heat wrap formed over them to secure them and to ensure that components like seven-segment displays with numerous pins do not have to endure the problem of wires touching.
11. The components can now be added to the circuit board and the ends of any wires must be stripped to be put through the drilled holes.
12. The components can then be soldered onto the PCB to secure them on the circuit. It should be noted that chip holders should be used for the chips and the chips themselves should not be located in them during soldering due to the damaging high temperatures.
13. All switches and LEDs etc can now be fastened into terminal blocks and chips can be put into the chip holders.
14. The circuit should now be operational and can be tested with batteries.

Product plan

1. To begin manufacturing, it is necessary to establish the dimensions of the circuitry so that it can be determined as to the required specifications of the product to contain it
2. The next step is to develop a concept further and come up with the desired final appearance of the product and its basic aesthetics. The dimensions will need to be established at this stage before any construction can begin.
3. Now that the desired shape and size have been decided upon, the next step is to create a split mould for vacuum forming. The first stage of this is to cut out 3 sections of MDF (medium-density-fibreboard) to the basic size of the length and breadth of the project on a circular saw.. Their dimensions are 150mm(W) 240mm(L). These must then be glued together using PVA (poly-vinyl-acetate) wood glue. In the middle of two of them however a piece of paper should be incorporated between the wood as it will be required later to be separated for vacuum forming. It is necessary to keep all of the pieces of wood as one entity at this stage as it will be essential for ensuring that the mould has consistent dimensions throughout. Once glued, it should be left in the vice for about an hour to dry sufficiently.
4. After the glue has dried, the shape of the mould can be sketched out onto the MDF. This can then be sanded down on the board faces until it has reached all of the lines and is uniform around its perimeter without any unwanted material jutting out. The cut out section at the top middle of the mould will need to be cut out using a hand saw as the hand faces will be unable to remove material from that area due to it being inhibited into the mould.
5. Once the mould's basic shape has been cut out, the next step is to file around the edges and corners with an hand file to ensure that the mould is slightly more rounded.
6. Once the edges have been filed, the succeeding stage is to go over the entire mould with sandpaper wrapped around a cork mould. This is to be done until all of the mould is uniform and smooth all over its area.
7. The circuitry has a number of inputs and outputs that need to be accommodated. This is achieved by marking out where they will be positioned on the front of the mould and then cutting them out to a depth of 5mm on the milling machine. The components that will be handled in this way include: Seven-segment-display x5, LED x3 and reset switch x2. This just covers the components to be used for the front of the product.
8. Before vacuum forming it is a good idea to coat the wooden mould with chalk, this is because it acts as a lubricant as thus makes it easier to remove the mould from the plastic once it has been formed without causing damage to the plastic.
9. After creating the mould, it can now be split by placing a chisel in the join where the paper was used and tapping it apart by impacting it lightly with a mallet, it can then be vacuum formed on the vacuum former using 1.2mm thick High Impact Polystyrene (HIP). As soon as it has been successfully moulded, it is then the task to immediately remove the mould from the plastic before it cools down or it could get stuck.
10. The split mould then needs to have all of the excess material removed using the gerbil, after this the edges will be rough, this can be remedied by going around the edges with some very fine wet and dry sandpaper.
11. To connect the two halves of the split mould together, a lip must be created. A thin strip of High impact Polystyrene needs to be cut on a guillotine and then bent around the inside of the mould. It is then fastened to the halves with pegs while it is glued with liquid solvent cement.
12. The cutouts for the circuit to be accommodated will then need to be carved out with a Stanley knife for the seven segment displays and then filed down with a small hand file, the LED's and switches will need to have their shapes drilled to the correct size, then LED clips should be put in so that the LEDs are held in position.
13. The product also has to incorporate the capability for supporting the two PTM switches located on the top of the device, this is accommodated by drilling 7mm holes and they are able to attach themselves as the particular specification of switch used has a thread and a nut so that it can be connected to the mould. The is also the need to accommodate the battery clips and the SPST on/off switch, these are both to be located on the left side of the product. A hole is to be drilled for the battery clips to have easy access from the exterior and the SPST switch needs to have a section filed out so that it can slot into position.
14. The circuit can now be attached to the mould, the seven-segment displays will need to be glued into position. After the circuit is fitted, the split mould can be connected together with the lip acting as the mechanism to hold them in place. If this is not secure, some tape corresponding with the mould's colour can be put along the join, this would also be effective for simply tidying up the join.

Manufacturing

Firstly, the mould was cut out at 150mm (L) 90mm (H) 60mm(D). This was then glued together with paper in between using PVA glue. This was then tightened up in the vice and left for about one hour under pressure. It was discovered that a depth of 60mm would not be sufficient to hold all of the circuitry, so an extra 15mm sheet of MDF was glued on.

The next stage of construction was to draw out the overall shape onto the mould and cut it out using the band saw. This was then made uniform around its perimeter using the band facer.

After the mould has been sanded, it can then be filed around its edges to give it a more aesthetic shape.

The next step is to go over the faces and sides of the mould with sandpaper wrapped around a cork sanding block.

The product then [illegible] appropriately sized holes [illegible] a 5mm depth to accommodate the PTM switches and the LEDs.

The indents for the seven segment displays can now be cut. It needs to have a piece of scrap wood fastened to the middle of the bottom of the device with double sided tape to hold it in the vice on the milling machine

The mould is then split using a chisel and mallet.

Chalk is applied to help the mould out of the vacuum formed plastic.

Moulds are then individually placed into the vacuum former.

After vacuum forming, the mould had to be removed from the plastic by impacting it on an open vice. The waste material is then removed using the band saw and the edges are tidied up with wet and dry smooth

[illegible] are cut out using the [illegible] round the inner edge of [illegible] and held in place with pegs [illegible] with liquid solvent cement.

The next process was creating the capability for the mould to hold the circuit inputs and outputs. The first stage was to cut out the notch for the SPST switch to slot into. This was done with an abra file cutting the basic shape and then using a small hand file to bring it to the correct size more accurately and neatly.

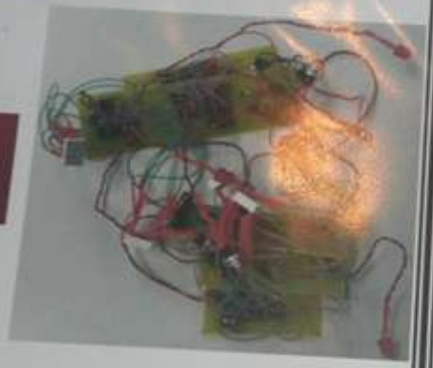
7mm hole is then drilled to accommodate the battery clips.

7mm holes are also drilled in the centre of the top two bulges for the PTM switches to be accommodated. Similarly to the previous drilling, it is essential to start with a smaller drill bit and gradually work upwards in size so as not to damage the plastic.

There next needed to be two more holes drilled in the bottom middle using a systems working up to a 7mm drill bit. These are for holding the two reset switches. The variety of buttons used means that their method of attachment involves unscrewing a nut, slotting the switch through to the other side and then reattaching the nut, thus holding it in position.

Manufacturing continued...

Windows are then cut out using a Stanley knife and neatened with a small square hand file. These are to hold the seven segment displays.



Holes are then drilled out for the LED's and LED clips are inserted into the holes so that the LEDs can be held in position.

The circuit required some modification before being put into the casing. The seven segment displays had been soldered with single core wire which is liable to breakages. This was replaced with multi-core wire and heat wrap was put over it to secure the connection. This same treatment was given to the three LEDs and the 4 PTM switches, these however also had their wires woven around each other so that they take up less room and are more manoeuvrable. The Astable and Monostable circuits were also joined together so that they could share a common on/off switch.

The circuit is then fitted to the casing with the seven-segment displays requiring araldite glue to hold them in position and the battery clips need to be removed from the terminal blocks whilst they are fed through the hole. Then the split mould is joined together using the lip. Then all of the protective film needs to be removed from the casing and finally the casing can be secured together using red tape.

Modifications made during manufacture

It was found during manufacturing that there were a number of issues with the initial intentions. Firstly There was an issue with the mould as it was established that it would not have the capacity to contain the required circuitry. This was remedied by making the mould deeper by adding another piece of MDF to it.

There was also another issue where a section of copper track on the circuit board was not conducting and allowing the current to pass through. This resulted in the seven segment display failing to get power. The gap in the track was established using a multimeter and was repaired by soldering a short piece of wire to the track to bridge the gap.

It was also discovered that there were a number of problems with the split mould. Due to the increased depth of the mould, the vacuum forming process resulting in the plastic being stretched thinly across the area. This caused is to become weaker and upon adding the rim, the plastic split along a corner due to another problem where the lip distorted the mould's shape and applying pressure to its weaker sections. Upon adding the Liquid solvent cement glue, it had a much stronger effect on the plastic and it melted right through and made the plastic very soft and discoloured around the edges. This problem was solved by using 2mm thick sheets of High Impact Polystyrene instead of the 1.2mm. This created a much sturdier mould.

A further modification which was implemented was the location of the device's on/off switch. This was initially located in the top middle section. Here the plastic was slightly weaker and the actual location of the switch on the circuit was on the left hand side. This resulted in repositioning it to the left hand side of the device beside where the battery clips are accessed. This was in itself another modification as the battery clips were originally going to be located inside the product but for accessibility reasons they were finally located on the outside of the product being fed out of a 7mm hole.

Testing of the final outcome

The products ability to be freestanding is perfect as it has a flat base which enables it to sit flat on the required surface. The weight of the internal circuitry enables it to be held in position better and it has the capability to be more durable to the threat of disc impacts. The accessibility and ease of use of the various switches was also investigated and it was fond that it was a little awkward to have to lean across the table each time there is a goal to hit the button to increment a scorer. However aside from this all buttons are very accessible and easy to activate.

Here the functions [illegible] scoreboard in terms [illegible] ability to be mounted are assessed. The product however does not have the ability to be fastened or clamped to the edge of the playing table meaning that it could get knocked off and get damaged. It also does not harness the capability to be hung from a wall meaning that its only possibility is to have it freestanding on the side of the table.

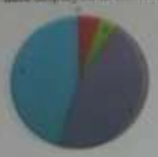
The Astable was tested individually to ensure that it operated as it should and that all of its corresponding components functioned correctly. It was realised that it all worked correctly and the counter incremented one at a time at a rate of one count per second meaning that is was an accurate clock pulse. The seven segment displays were of an acceptable brightness and thus easy to read off and the reset switch worked correctly.

The monostable was then tested individually to establish that it worked accordingly and that all of its necessary interactions functioned correctly and how visible it is. It was established that the circuitry for the monostable all worked correctly and the counters easily incremented up to nine. The seven segments were very clear and easy to read off. However the LEDs were not very bright and were difficult to see which could cause problems during game play as it is used to indicate the winner.

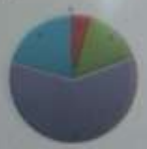
Evaluation

Function:
The final product fulfils the criteria of its functional requirements very well as it achieves all that it original set out to incorporate. Its capability to score the game and time it simultaneously works very well although it requires the use of two batteries. All of the exterior operating components function correctly also with the buttons on top incrementing the score and the buttons on the front both operate successfully as reset switches.

Aesthetics:
The aesthetics of the product are very appealing, it has a unique modern shape which would fit well into all environments. It incorporates a bright attractive colour scheme. It has a smooth surface. The layout is symmetrical which adds to its overall attractiveness. I also conducted a questionnaire* to investigate further and gain the opinions of others. I interviewed 20 people, for the question "What would you rate this product out of 5 in Aesthetics" I received the data displayed in the following pie chart.
This chart illustrates that on the whole, the product was well received with 9 people giving 4/5 and another 9 people giving it 5/5. The last question was open so that opinions could be given, some of them talked about not liking the colour scheme which is possibly part of the reason why a 2 and a 3 were given.



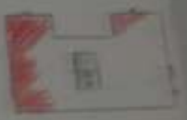
Ergonomics:
The ergonomics of this product are average as there are a number of issues encountered during testing. Its lack of ability to be fastened to an air hockey table is disadvantageous as this means that it requires for the product to be held whilst reset buttons are activated so that it is not knocked off the table. It does however have a number of features which are quite ergonomically satisfying, the seven segment displays for instance are very easy to read off as they are very bright. In the survey conducted I asked the question: "What would you rate this product out of 5 in ergonomics."
The results to the question are displayed in this pie chart.
It shows a set of results mostly biased towards 4 with 12 people choosing this answer suggesting that people were honest and acknowledged some of its flaws.



Safety:
This product is relatively safe when used appropriately. There are no sharp edges which people could get cut on. It does have detachable small parts in the form of batteries, so this product should be kept out of reach of small children. It is made of non-toxic materials. The power supply is a low voltage so there is a negligible risk of a shock. The materials are shatter resistant so that if a disc causes a significant impact, pieces are unlikely to chip off.

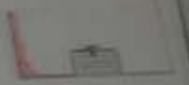
*A copy of the questionnaire can be found in the appendices.

Modifications and Future improvements



1. There are a number of changes which I would make if I am to undertake this project again. Firstly, I would incorporate means by which the unit can be attached to either the wall or an air hockey table by means of some sort of hanger for the wall and/or a bracket or clap to hold it in place on the actual table itself. This would mean that the device would be much more secure and would be safer as it is at less risk of taking damage from falling etc.

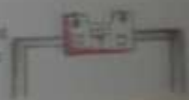
2. Another modification I could incorporate would be to implement methods to downsize the circuit, as due to its large size, it could not be stacked with spacers or mounted on foam meaning that it was a little untidy. Methods to modify it to make it less bulky include: modifying the PCB so that there are less jump wires and bringing tracks closer together so that the actual circuit boards can be smaller. It would also be useful to have the seven segment displays fitted into holders directly on the circuit board as this would significantly reduce the volume of wires all over the place.



3. The location of the battery clips would also be beneficial to change to an operable compartment on the housing as it is more aesthetically pleasing as there aren't battery clips hanging out the side all the time. Also it will become less of a hazard to young children who are liable to choking on small parts as they will be harder to get at for infants this way.

4. I would also reconsider the colour scheme as in my questionnaire there were a few different comments relating to a dislike of the colour scheme. Possibly, research could be conducted beforehand to establish the most popular colours to use.

5. I could potentially incorporate a system where the trigger inputs for the monostable are activated whenever someone score a goal via a micro switch located at each players goal this would mean that players would not have to do so much manual operation of the scoreboard.



6. Another modification could be to have the unit suspended across the centre of the table where it can be viewed more easily. It could possibly be achieved by incorporating an aluminium bar bent in the vice across the unit and then secured at each side of the table by a clamp, bracket, or suction cups etc. One potential detriment of this is however that the circuit's out pouts would need to be replicated so that each player has a view of the time and current score. This may require increasing the size of the mould and also incorporating more batteries to drive the increased amount of outputs.

Problem Identification

It is very widely known that the first years of a child's education are the most crucial. During these years in their lives children will learn up to 80% of everything that they will ever know, for this reason it is very important to have a good early education system. "*For the children who are too immature for a school environment — for example, the summer births — some can quickly become disengaged with the learning process and some remove.*" – Belfast Telegraph, 19/10/09.

It is evidenced that the easiest way to get young children to concentrate and be educated is to make it enjoyable and let them know that a classroom is somewhere that they can enjoy. Under the new education system brought in on 1st of September 2009, the focus is on thinking skills and personal capabilities with much more play-based learning at key stage 1. "*Dame Gillian Pugh recommended that children in England should start school aged six years and called for the play-based learning now in nurseries to be extended for another year.*" – Belfast Telegraph, 19/10/09.

Nowadays in special schools, such as Glenveagh for children with disabilities it is always important to find easy, enjoyable means of education for the students. With a range of disabilities within the school, ranging from cerebral palsy, rare genetic disorders and problems that stem from conditions at birth, these unique schools are always looking for new exciting ways to keep their students happy in a good learning environment. The students at Glenveagh are of all ages, ranging from 5 years old up until 18 years old, this means it is important to have activities they can all join in with, individually or in groups.

The Qualifications and Curriculum Authority (QCA) of the United Kingdom has set learning objectives for the years 0-5 years old. These objectives are split into six separate categories, personal, social and emotional development, communication, language and literacy development, mathematical development, knowledge and understanding of the world, physical development and creative development. The categories taught mainly by schools or nurseries are development of communication, language and literacy, mathematical development and creative development. It is important that a young child is given the correct tools and guidance in schools or nurseries to develop in these areas. If the child does not get to the correct level of education and meet the QCA learning objectives they will be affected and possibly struggle in primary or secondary education.

The development of communication, language and literacy includes sustaining attentive listening skills, experimentation of new words and meanings, interacting with others, sounds of words, basic writing and understanding of text skills. To help the child in this category, role playing and learning by doing methods are relied upon, for example group reading sessions will give the child confidence to read in front of others.

To develop mathematic skills at an early age the children must first learn how to count, use and recognise the words from 0 to 10 in everyday life. Comparing words such as lighter than or heavier than are taught to help put numbers into context. Basic shapes and sizes are taught to children.

A child's creativity is a very powerful thing, to bring out the most of a child's creativity schools and nurseries must make different tasks and activities for the children to try, with teachers giving them the guidance along the way. Colour, textures and shape are all taught in both two and three dimensions. A child's response to what occurs around them is vital to their understanding of the world. Most schools or nurseries find it hard to keep up with the development and outstanding creativity of their students; it is very difficult to have one activity which all the children will develop from equally.

Special needs can relate to a large amount of diagnoses such as learning difficulties, mental slow or terminal illnesses, these diagnoses can prevent good concentration levels in most disabled children. It is the ambition of the special educational needs (SEN) that every child with disabilities or SEN reaches their full potential in school so that they will be able to make a successful transition into adulthood and higher education, training or career opportunities.

The goals and targets for children with disabilities in special schools varies slightly, they are varied from student to student. The Individualised Education Program (IEP) sets goals developed during IEP meetings between the school and parents, the attainability of a special education student's goals is essential to their success and development. The IEP sets goals on a yearly basis and the students are given the extra attention in special schools that they need to reach their personal goals. There will be a few major or larger goals alongside smaller, minor goals to ensure simple things and basics are achieved in every category of development.

Targets for special school students take more work to achieve, the students receive more one to one attention from teachers, it also helps if students get along with each other and have fun together, this enables them to learn from each other. To enable students with learning difficulties the chance to reach their full potential and meet all of their goals on a yearly basis the school must provide a good learning environment. Children love to play and have fun; this is why toys are very useful and well used in special school classrooms. Children have learn best when they are enjoying themselves. The use of games and toys expands the student's creative and logical thinking, these are very desirable traits in everyday life. Group games help the students become more social as they can interact with each other whilst learning.

GLENVEAGH School

The toys used in special schools must be safe for their young students to use daily. They keep them large enough so the students can use them independently without harm; also the toys are a sensible size so that they can be stored easily when not being used. To enable good use of the toys and games by the students the teachers allow only a short amount of time for children learning with a single toy. The children switch from toy to toy to stop boredom; this keeps up their interest in learning and maintains their concentration. All of the equipment used in nurseries and special schools is bright and colourful to attract the students and entertain them.

Design Brief

I have decided to design and make an educational electronic toy for the students of Glenveagh special school, it will be aimed at the students from the ages of 3-5 years old. The housings should be no bigger than 800mmX600mmX200mm. The product must attempt to keep children's concentration for at least 60 seconds. The product must be fun and entertaining with a focus on teaching the concepts of shapes and colours.

Specification

-Function

1. The product must be exciting so that students will want to use it a lot and learn from it time after time
2. There must be at least two different levels of game difficulty to keep the students interested in the game for one minute
3. The game must be mind focusing and the student's concentration must be tested, but not strained
4. The game must efficiently teach the students about shapes and colours to help them reach their personal IEP goals
5. The game must be fun while retaining a healthy balance between work and play
6. The circuit must add a new dimension to the game, giving it added excitement and letting the user know what is happening, when the game is finished and how close the task is to finished
7. To ensure the game is shared between all the students the time limit must be displayed within it for each time it is played, this will help the students learn to share with each other and they will all get a turn. Also outputs must be displayed to show the end of the game, either with the game being completed or the time ending
8. The task must be completed with all blocks in the correct places in 60 seconds otherwise the buzzer sounds and its game over
9. The buzzer to let the user know the game is over must sound if either the blocks are in the correct place, if the time runs out or both
10. The toy must have more than one activity of fun along side the education game; the toy must resemble and act like an original child's toy

-Aesthetics

1. A well known theme to children from a children's television show or Disney movie should be used to catch the student's attention
2. The materials used must be aesthetic and bright as it is for young children and it can be difficult to get their attention
3. The area around the timer and score displays must be a colour that makes the displays stands out so that they can be easily seen
4. The shape of the main housing for the product should be a creative shape to stand out from the other toys and games in the classroom
5. A wide range of colours must be used to show different areas of the game to give children a clue of where to put pieces and what do to with parts
6. The inputs and outputs must be of bright colours to stand out and let the students know what is happening to help them understand and get used to the game quickly

-Ergonomics

1. The product must be easy to use, and be easy for the students to get used to
2. All of the moveable parts of the toy must be an ergonomic shape to fit into a small child's hand so the game can be easily played
3. No separate part should be bigger than 70mmX100mmX30mm to enable the child to comfortable hold it. The average span size of a small 5year olds hand is about 100mm from wrist to middle finger and 60mm from the tip of the thumb to the tip of the little finger
4. For easy use by children with disabilities the parts must be easily held and gripped

-Anthropometrics

1. To ensure the students can comfortably make use of the educational toy most efficiently it must be able to be used at a desk while sitting on a chair
2. The average arm length for a child between the ages of 3-5years old is from 170mm-200mm. Students must be able to reach across from one end to the other of the product. This ensures that the user can quickly access all areas of the game
3. For students with strong physical disabilities playing the game must not put any strain on their bodies
4. To be used on the floor the toy must have strong feet on the bottom of it to keep it off the ground. To be lifted and stored by teachers the product must be a good size for the teachers to grip and hold

-Materials

1. The product must be made from three different materials in a wide range of colours so that it is durable, strong and aesthetic
2. The materials used must be hygienic to avoid any potential illnesses to children with weak immune systems in the classes
3. Materials used must be smooth so it has a nice feel and touch to it and the students are not in danger of hurting themselves when using it
4. The product must have a good finish with no sharp edges or splints
5. The materials used for the main housing of the product must be light so it can be easily lifted onto a desk for quick use
6. To be used by young children the materials used for moveable parts of the product must be lightweight and strong so they can be easily picked up and placed

-Size

1. The product must be no larger than [illegible] in dimensions so that it doesn't take up too much room and it can be [illegible] when it isn't being used
2. To ensure that the product is safe to use [illegible] 45mmX25mmX5mm. The parts of the toy [illegible] this is to ensure the students do not [illegible]

-Weight

1. To ensure the product is easy [illegible] 3kg, this will ensure it [illegible]
2. The overall weight of the toy [illegible] it is heavier on one side it will [illegible]
3. The bottom of the toy must [illegible] where it is being used, the toy [illegible]
4. No separate piece of the toy should weigh [illegible] the children can lift and use each piece of the toy comfortably

-Safety

1. To be used in a multitude of environments, the product must be [illegible] strong as it needs to be to ensure it is fit for its intended purpose. This will ensure the smooth edges are retained and no sharp edges are formed or parts broken off
2. Any separate parts from the main body of the design must be safe to use, they must not be small enough for a child to swallow and choke on, this is very vital to the safety of the design
3. No piece of the design should separately be smaller than 45mmX25mmX5mm
4. All electrical cables should be neatly inside the body of the design, this will ensure there is no electrical danger for students using the product. The only parts of the circuit available should be visible then inputs and a visual output
5. To avoid children from ever getting near the electrics, to change the products batteries or repair the product, the back or bottom must be removed by a teacher or adult
6. There should be no bare wire anywhere within the design; this is in case of danger to a teacher or volunteer changing batteries

-Circuit

1. The circuit must be small enough to fit inside 300mmX300mmX200mm casing. This is to ensure the product can be a suitable size
2. The circuit inputs must be clear to see and easy to trigger, large push buttons must be used as they are easier to press
3. The output of the circuit must be able to be seen or heard clearly, the outputs must be large and loud to maximise how well they can be noticed
4. The circuit must be able to perform many functions at once to make the game interesting and exciting. The students will be get bored of the same [illegible] repeating itself
5. There must be a timer to count down 60 seconds with a buzzer to sound [illegible] it finishes, letting the user know that the time is up and the game has finished
6. No part of the circuit should be visible from the outside of the housing [illegible] from the inputs and outputs. If the circuit wires were out they [illegible] with by the children and become dangerous
7. To ensure the circuit is kept working there must not be any part of the board in reach of the students, the circuit would be easily damaged if [illegible] covered by the housing
8. The circuit must be accessible for maintenance work by [illegible] housing must open with a screwdriver to give access to the circuit [illegible] components
9. The battery must be easy to change by the teachers when the toy runs out of battery; this ensures the product is not prevented from being used for too long. A common type of battery available in many stores and garages must be used to ensure the product is easy to keep using

-Mobility/Storage

1. The product must not slide across a surface when it is being used. [illegible] feet must be used to keep the product in one position while in use
2. For storage the product must be easy to be picked up by teachers. The average hand size of a female adult is about 170mm from wrist to the tip of the middle finger and 130mm from the tip of the thumb to the tip of the little finger. An average male adult has larger hands of about 190mm from wrist to the tip of the middle finger and a span of 180mm from the tip of the thumb to the tip of the little finger. The product must fit the hands of an adult and not a child so it is easy for the teachers to pick up but difficult for a student to pick up
3. For good mobility the product must weigh no more than 3kg

-Durability

1. The product must be made from durable materials so that it does its job well and is safe to use for a long time. If its starts to break or wears it may become unsafe for young children to use with the corners becoming sharper and the housing of the circuit becoming weaker. To ensure this does not occur and the product must have a life expectancy of at least 3 years. This can be achieved by using strong materials such as metals and plastics

-Environmental

1. The product must be as environmental as possible so the product to ensure it can be easily and safely disposed after a number of years

-Testing

To ensure the product is safe to be used in classrooms I will run some tests to ensure all of the functions are working and the housing is strong

1. The inputs must be tested to ensure they alter the correct outputs needed
2. The outputs must be clear to see and hear from at least 10m away from the product
3. The housing must hide all wiring and circuit components
4. The wheels of the product must keep the game steady on a table or on the floor whilst being used

LeapFrog Fridge Phonic

-Function and Purpose

This product is a fridge magnet which helps children from the ages of 2-5year olds to learn their alphabet. It has a voice output which is activated by selecting a letter to place on the reader, it helps give the correct pronunciation of letters and it can sing the alphabet.

-Features

1. Help reading skills rise and shine with this magnetic letter set
2. Introduces children to letter names and sounds
3. Features big, bright letters that are easy for little fingers to grasp to help develop fine motor skills
4. Sing along to the Alphabet Song
5. Playful phonics songs help children remember the sound each letter makes
6. Includes magnetic letter reader, 26 magnetic letters, and 3 AAA batteries

-Fitness for Purpose

This simple fridge magnet is very effective at teaching young children all about letters. The reason it is very effective is that it is bright, colourful and clear to read, all of these factors help it to stand out clearly on an average plain white fridge door.

As this product is situated in the kitchen, one of the most used rooms in a house, it means that it can be used with ease by children both independently and with a parent's guidance. The LeapFrog Fridge Phonic comes with a very fun aspect to it, this helps the children have fun ad makes it a better environment in which they can learn. Children will be very entertained by this toy, singing along to the alphabet will keep them focused and interested, making this a great way to learn. It is very visual as the letters are very clear and easy to make out.

The pronunciation of some of the letters may not be one hundred percent understandable for young children. If this toy is mass produced, the accent of the voice pronouncing the letters or word may cause confusion for young children; this would mean it was an inaccurate learning device.

-Aesthetics

The LeapFrog Fridge Phonic is made with a large amount of plastic. This gives it a cheap look and doesn't show off how good the product is or how much a child can learn from it. Despite the cheap plastic look, it is bright and colourful, this is enough to catch the eye of a child, and that is the most important thing. The shapes used of the sun and cloud are very easy for a young child to relate to and recognise.

-Ergonomics

This is a product built to be placed on a fridge door and would not need to be help. Despite this the design would be awkward for young children to hold or get a grip of if they tried to move it about. The product has no sharp edges, the points from the sun have been rounded, this ensures the product is safe to be used by children.

-Materials Used

The LeapFrog Fridge Phonic is made using very inexpensive acrylic plastics, these provide the essential bright range of colours needed for a children's toy. The acrylic is not very robust, it would break if it were to fall off a fridge door from height.

The Materials used in all parts of the toy enable it to be easily help by a magnet.

-Industrial Process

This product main housing is made through a very simple and effective manufacturing process. It involves injection moulding, this enables the toy to contain intrical and complex shapes to make it more appealing.

The letters are done using a different injection mould, but it is the same process. The buttons are vacuum formed to give a simple look with a good finish.

All of these processes make use of lightweight materials to enable the product to be held to the fridge with a magnet.

-Rating

The LeapFrog Fridge Phonic is a very clever design and I particularly like the fact that there is a human voice coming out of it, ensuring the children feel comfortable using it. I will look to make a product that children are comfortable with.

V Tech - My First Alarm Clock

-Function and Purpose

My First Alarm Clock is an educational toy which is for children between the ages of [illegible] digital alarm clock with a 12 hour display and moveable clock hands for [illegible] toy teaches children about time and time concepts in a fun and interactive way. It can also [illegible] personal alarm clock with special times of the day and dates being set.

This you includes a pet, "chirpy the bird", an alarm clock bird which comes out at [illegible] new dimension to the game as he must be fed and well looked after in order to [illegible] running smoothly. This encourages responsibility and awareness of routine.

-Features

1. Real digital 12 hour clock
2. Includes digital and analog [illegible]
3. Fun interactive bird pet, [illegible]
4. Introduces time concepts, [illegible] playtime
5. LCD animated screen
6. Moveable classic clock hands [illegible]
7. 8 alarm settings

-Fitness for Purpose

The V Tech - My First Alarm Clock is perfect [illegible] exciting features which will keep children entertained for hours. This toy includes very visual effects and bright colours. The buttons are of a good size with good spacing between them to be used by children with ease. The [illegible] are varied on a white background [illegible] individual, teaching the different [illegible]

As in a normal everyday clock, the small hand is for the hour and the big hand [illegible] the children for using a real clock. The head up display is very clear, although very [illegible] would be unable to understand what the display meant.

Children will be attracted to playing with this toy by the cute little bird resting on the [illegible] recognisable to children and will make them feel comfortable with using the V Tech - My First Alarm Clock. On the other side of the toy lies the power button which is easy to see and big enough to be easily pressed. The buttons and clock hands used for this toy means that children can play with it independently due to its simplicity. The main housing and colour of the toy is not attractive or appealing, the purple is not a good shade and takes a lot of the brightness out of the overall colour of the toy. The purple is dull and would not help encourage children to play with it. The V Tech - My First Alarm is a very thin product, which could be easily knocked over and is very unstable if being used on the floor with no backing support.

-Aesthetics

The overall look of this product is poor, despite having some attractive friendly features and buttons, all the good is shadowed out by the dark, dull purple plastic which surrounds the whole product. The buttons are well rounded and made of plastic to give them a good finish which is essential to ensure children that will not be concerned about poking and pressing them. The use of multi-coloured bubbly numbers on the clock face is exciting and looks inviting. The two clock faces have been made with different colours of plastic to distinguish between the hour hand and the minute hand; this is a good tool to aid the learning process. This product is made with too much plastic and as a result has a cheap look to it.

-Ergonomics

The V Tech - My First Alarm Clock is a very large children's toy, it is to be played with on a desk as it is not easily moved around by young children. Because of the working clock mechanism and the timing circuits needed the product is fairly heavy and could only be comfortably lifted by an adult or carer. The shape of the toy allows adult sized hands to get a good grip on it but not for children, this is good as young children have the potential to be clumsy.

-Materials Used

This product housing and its buttons are made using polythene as it is hygenic and can be very easily moulded into the needed shape. The outside of the clock is created using stainless steel as it has a good finish and is strong to protect the circuit behind.

-Industrial Process

The clock housing is made through the process of vacuum forming as it makes use of good materials like polythene, the buttons are vacuum formed separately and then joined to the housing. The clock is made through the steel casting process and joined to the front of the housing after completion.

-Rating

This educational toy has too many features to be used by children, it will distract them from learning with too many features. The use of colour is very good, apart from the dull purple. I will be looking to keep my design very colourful and simple, both in the design and human interaction.

Existing Ideas

The Wooden Educational Shape Sorter

-Function and Purpose

The Wooden Educational Shape Sorter is an educational toy aimed at children from the ages of 2-5 years old. The Wooden Educational Shape Sorter consists of a main cube body and 8 smaller blocks all of different sizes and shapes. It is a great way to teach children about different shapes. The aim of the game is to slot the pieces into the box in the correct places, if not they will not fit, this indicates it is incorrect.

-Features

1. The main body of the toy has dimensions of 130mmX130mmX130mm
2. It is very light and only weighs about 1 kg including all of the parts with the main body
3. The smallest separate part of the product is of dimensions 70mmX50mmX40mm
4. The separate blocks can be placed in the main body for storage
5. The lid of the toy can be removed to get the blocks out to play with

-Fitness for Purpose

This toy is very well suited to its purpose, it is a simple game which gets the most out of child's mind in a fun way. The shapes attract the child's attention. The main body of the product is a simple plain white wooden colour, letting the child distinguish between the parts to play with and where to put them. The Wooden Educational Shape Sorter can store all of its parts into the small main box for easy storage, it is also very light which makes it very practical.
The down side of the Shape Sorter is that the main body of the toy is very brittle and must be used with care, this can be difficult when children are using it. If the toy was mishandled by a child it would be very easily broken.

-Aesthetics

The Wooden Educational Shape Sorter is designed using bright pieces to make it eye-catching and appealing to children. There is a large mixture of a range of basic and unusual shapes to play with making it exciting to use every time.
The simple design does not confuse the children using it; you can almost guess what to do by looking at it.

-Ergonomics

The shape and size of this toy help give it good ergonomics, with the parts out of the box it can be easily gripped by putting a hand through one of the holes in the box and simply lifting it out. Although when the parts are in the box there is no place to grip and it is difficult to hold the box in one hand.
The parts are good sizes and shapes to be easily gripped as a child's small hands. The box is slightly too big for a child to lift, some of the children would be able to spin it around for easy use and to get at different sides. The size of the box means it is a good easy size to fit into an adult or teacher's hands.

-Materials Used

The Wooden Education Shape Sorter is made using pine for the box and using European white beech which is painted over with many different colours. These materials are very light. They are not very strong or hygienic for children to use.

-Industrial Process

The box of this product is made by cutting 4 sides of pine joined to each other and a bottom piece with finger or dovetail joints. The lid would be cut to slide over and cover the top of the box.
The awkward parts would be manufactured using CAM or a CNC machine.

Digital Teaching Cash Register Toy

-Function and Purpose

The Digital Teaching Cash Register Toy teaches money and basic math skills with a talking, interactive cash register. Students will have fun practicing coin identification, addition, subtraction and place value as they play four featured games that increase in difficulty as players advance their math skill levels. It is also great for pretend play exercises and learning basic calculator skills.

-Features

1. Transactions are rewarded with lights, sounds & voice messages
2. Built-in games teach Coin Identification, Addition, Subtraction and Place-Value
3. Coin reader identifies real and included plastic play coins
4. Checkout scanner with sound alerts
5. Real working scale
6. Large LCD screen shows real-life transactions with big, easy-to-read numbers
7. Check sum total

-Fitness for Purpose

This toy is a great learning device for children between the ages of 2-6 years old. All of the features on the toy make it as real as a toy can be, giving the child a real sense of working a till. The sounds and alerts make the game interesting; children learn by linking sounds to parts of the toy with voice messages helping type and reading out numbers. This is a very efficient education toy and it does its job well because it is interesting with endless calculations and [illegible] a real working scale.
The Digital Teaching Cash Register Toy has most of its weight at its base with rubber feet to minimise sliding while it is in use. All the small plastic play coins can be stored in the till when not being used as to ensure they are not easily lost. The large digits on the display are ideal for children as they are big and easy to see. The correct mod is well hidden within the housing, it is safely out of the way but accessible for an engineer with a screwdriver.
The toy weighs about 5kg which is too heavy for a child to lift and break, if the toy was to fall off a shelf it would be very dangerous as it [illegible] a child's foot. This would give the child a bad image of the toy and it may be neglected. As the toy is very heavy it is difficult to lift and store on high shelves. The toy has a very short battery life and is expensive compared to most to maintain.

-Aesthetics

The toy is mainly of a dark [illegible] with bright buttons to make them stand out and draw attention to them. The fruit are real life colours making them recognisable to young children as they know what they are weighing. The most important buttons such as the one to open the till and get money out is a separate colour to [illegible] to stand out as a special function. The shape of the toy is boring, but it is of the shape of a till making it authentic and enhancing a child's fun using it.

-Ergonomics

On the till there are many small buttons packed together, this makes it difficult for children to single out the button they want to press, making miscalculations and feeding the children the incorrect information to the screen, this is especially difficult for special needs children using the Digital Teaching Cash Register Toy as many have weaker co-ordination. The product is difficult for adults and teachers to grip or get their hand around, this could make lifting it up onto a shelf very difficult.
The fruits, plastic play coins, plastic play swipe card the till itself are all smaller than usual. This makes them ideal for children's use, it makes it easier to hold and work with small money as they have smaller hands. The money compartment in the till has sections to fit the size of the money, they are also big enough for a child to put their hand into and take coins out of.

-Materials Used

This till of this product is made from high density polythene, it is very strong and rigid which makes it suitable to hold a circuit and many plastic coins. The plastic play coins and the plastic play swipe card are made from polyethylene or rigid polystyrene; these are very sturdy and light materials. The plastic food is made from low density polythene as they must be flexible and non-rigid like real fruit.
All of the materials used in the Digital Teaching Cash Register Toy are very hygienic and safe for children to use; they have a long life expectancy and are very durable.

-Industrial Process

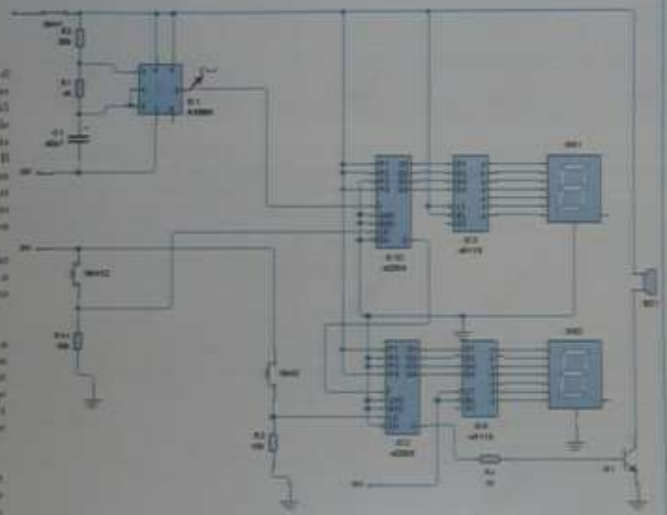
The main part of the till would have been vacuum formed, this allows for the integral shape of the till with space for all the buttons. The process of injection moulding is used to make the plastic play coins as it can repeat exact replicas over again and again. The plastic play swipe card and the fruit are manufactured through the process of injection moulding also.

Initial Ideas – Circuits

Counter Circuit

This is a counting circuit which is used to count down from 60 (1 minute/one minute). The counting process is started by the user or child pressing the start button which begins the astable 555 counting circuit to create a pulse every second. The 555 astable chip output is connected to a 4516B. That provides the outputs needed to illuminate the 7 segments displays along with a 4511B driver chip to show the count. The 4516B is used along with an identical counter set to count down from six. When the first count reaches 0 pin 7 of the 4516B goes low and with an inverter triggers the six to count down one to five, this gives a count from 60 down to 00.

Once the count 00 is reached and the count is over, the output from the second 4516B goes low and with an inverter triggers a buzzer to sound, letting the user or child know the timer to complete the game is up.



The circuit design is very simple and could easily be used for a children's toy as there is no human interaction to cause confusion with the circuit. The game is completely separate from the circuit and has no effect on it. This means that if the child completes the game before the time sounds out and the buzzer sounds the circuit will keep counting, this could make children feel maybe the game isn't over or they haven't completed it properly.

A reset switch or stop button could be added to this circuit to reset the count back to 60 seconds when the child has completed the game. This could be a push button which the child could press after completing the game.

Logic Circuit

The logic in this circuit is made up of two eight-leg NAND gate [illegible] two-leg NAND gate. The output of the eight-leg NAND gate is low [illegible] of its inputs are high. This output is connected to both inputs [illegible] NAND gate. This is the truth table for a two-leg NAND gate.

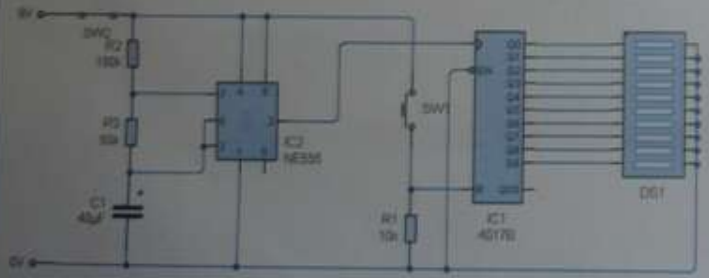
A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

Through this [illegible] found that if both [illegible] from the low [illegible] NAND gate [illegible] NAND gate [illegible] that were [illegible] The child's task [illegible] the logic [illegible] output of the [illegible] a buzzer to [illegible] completed. [illegible] The inputs for this [illegible] from the child completing a simple puzzle or jigsaw and placing the parts in the correct place on top of push to make (PTM) buttons.

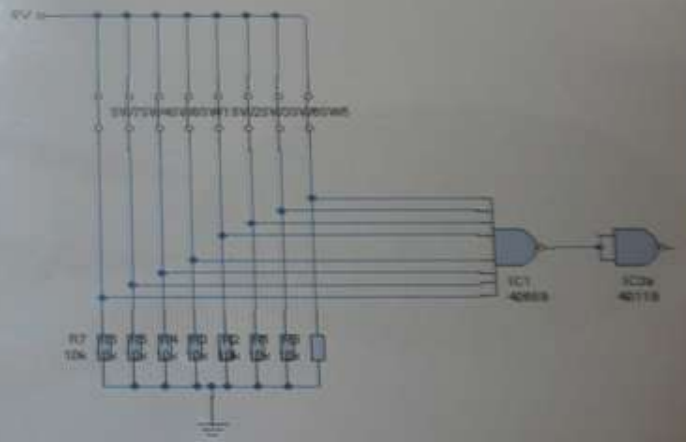
This circuit is designed to make the game as interactive for [illegible] possible, making it more fun and playable for them. Children will [illegible] this game as it will test their creativity and colour skills. Children will not be put under any pressure to complete this game, making it less challenging. It does not help children to learn as they are not pushed to think quickly. The lights and buzzer used helps the children by clearly showing them what stage of completing the game they are at.

Chaser Circuit

The chaser circuit works using a bar graph display, creating a row of lights which will gradually go from the top to the bottom over one minute (60 seconds) until the LEDs get to the bottom and the last LED goes off. A 555 astable timer circuit creates the [illegible] 4511B to turn one LED off every 6 seconds until all the LEDs are off. After the last LED goes off a stop LED goes signify the time for the game completion is over. The LEDs change in colour depending on how close to the buttor from green and changing to yellow, amber and finally red to show time is almost up.



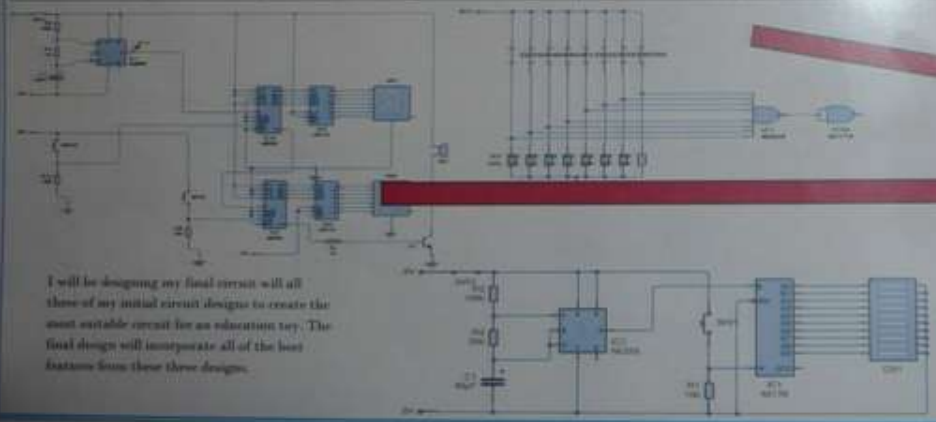
The use of [illegible] circuit makes it [illegible] children to see their [illegible] getting closer and closer to the time limit set. Apart the circuit has no connection to the game and would continue to time after the task is complete by the child. The buzzer and stop sign are clear signals that time is up and the game is over. As there is no connection between the game task and the circuit the user may not feel under pressure to complete the task because nothing they do has influence on the timer. This circuit would make the toy very non-interactive.



Evaluation Against Specification

Circuit Point	1	2	3	4	5	6	7/8	9	
Counter Circuit	✓		✓		✓	✓	✓	✓	Initial Housing 1
Comment	This circuit design will easily fit into a housing of suitable size	The design of this circuit is very intricate, meaning the components must be kept small in order to keep the size down	The buzzer will be easily heard, the 7-segment displays used are big enough to be seen by young children	This circuit is only a timer using 7-segment displays to count down from 60 - 0	This circuit has a digital timer with a buzzer to sound when the time runs out	The wires and internal components of this circuit will be easily contained within the housing to increase safety	The circuit board itself will be kept within the housing, but will still be accessible for professional maintenance	The battery is easily fitted to be accessible to teachers to change it without much time	Initial Housing 2
Chaser Circuit	✓	✓			✓	✓	✓	✓	Initial Housing 3
Comment	This circuit design will easily fit into a housing of suitable size	There are few inputs so they will be easy to see and can be enlarged to increase ease of use	The buzzer and stop sign are clear signals that time is up and the game is over. The bar graph is very small and difficult to see	This is a simple visual timer and has no user input	There is a visual timer with a buzzer to sound when the time runs out	The wires and internal components of this circuit will be easily contained within the housing to increase safety	The circuit board itself will be kept within the housing, but will still be accessible for professional maintenance	The battery is easily fitted to be accessible to teachers to change it without much time	
Logic Circuit	✓	✓				✓	✓	✓	
Comment	This circuit design will easily fit into a housing of suitable size	The logic gates need low inputs as input which can come from a wide range of input components, large input components will not make a difference to the circuit	The buzzer is loud and easy to hear, there is no visual output to show the end of the game, this means that this circuit would not be able to be used by children with hearing disabilities	The logic circuit design has lots of user interactivity and user inputs, this is what the logic circuit depends on to make it work, there is no timer or other function	No timing circuit function is used in the logic circuit, only a buzzer to sound when the time is up	The wires and internal components of this circuit will be easily contained within the housing to increase safety	The circuit board itself will be kept within the housing, but will still be accessible for professional maintenance	The battery is easily fitted to be accessible to teachers to change it without much time	

All of these circuit designs would need improvements made to them if they would be suitable for the circuit built/ created for my educational toy. In the [illegible] be interesting I will need more [illegible] those circuit designs [illegible] ensure my final toy is as interesting and entertaining as possible. I feel that combining the two functions seen here in these designs, the logic and the timing circuits would help improve the dynamics of my final [illegible]



I will be designing my final circuit will all three of my initial circuit designs to create the most suitable circuit for an education toy. The final design will incorporate all of the best features from these three designs.

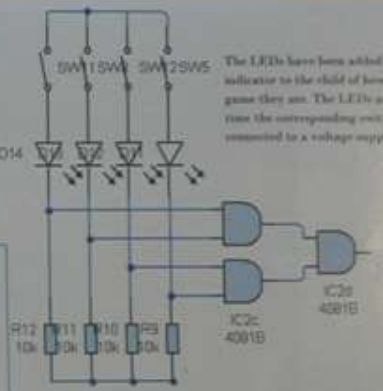
Development - Circuit

Circuit Details

My circuit must carry out a timing action, while also being interactive for the child using it. The circuit must be small enough to fit inside my chosen housing, to ensure this the circuit must be designed as compactly as it is safe and possible to do. The circuit must be tidy and well organised so parts of it are easy to locate.
To ensure the interactivity of the game for the child, the circuit must react to everything the child does, from pushing the start button to creating an input; all inputs must be met with a complimentary output.

To further simplify and develop this circuit I have taken out half of the inputs the child will control. The game and logic are still the same. The lower amount of controlled inputs for the child means that the game is less of a challenge to complete, also the number of inputs in this circuit makes it very simple to set up the logic gates needed for the circuit.

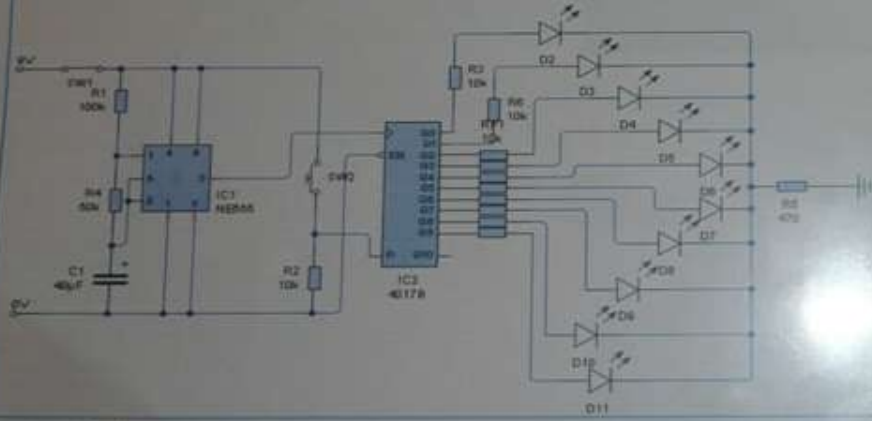
The logic gates I need to create a high output only when all of the inputs are high are a series of AND gates. The AND gates used are all part of one chip, a 4081B, this decreases the amount of chips being used and frees up space to make the overall size of the circuit smaller.



The LEDs have been added to the circuit to [illegible] indicator to the child of how far along in the game they are. The LEDs are [illegible] time the corresponding switch is pressed. [illegible] connected to a voltage supply.

Chaser Circuit Development

This circuit initially displayed the count remaining in a bar graph; the bar graph would have been very small as it is not available to me in large sizes. I decided to change the bar graph display for 10 separate 10mm LEDs to make the count clearer to the child using the toy. Another advantage to using LEDs over a bar graph display is that the LEDs have more freedom and can be made to create any shape, whereas the bar graph display would have all of its internal LEDs in a single straight line. With the new freedom of the LEDs I can place them almost anywhere on my housing, being creative and making the overall toy more appealing and exciting to children. The count has been kept the same, one pulse from the 555 timer into the 4017B counter to change down one LED every 6 seconds. As there are 10 LEDs the time to finish the count will be one minute (10 X 6 seconds), this agrees with my specification for the time for the game to finish.



With the improvements there is still no interactivity with the child, the circuit can't tell when the child is done, so there is no pressure on the child to finish the game, the [illegible] can be easily ignored.

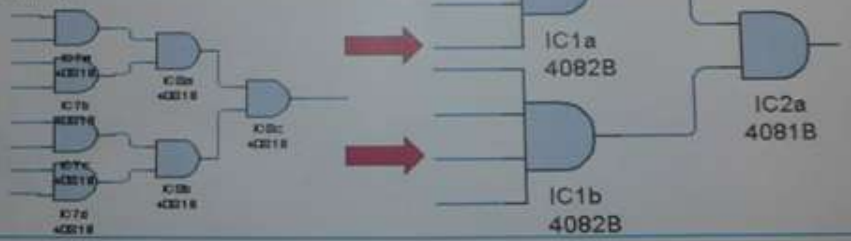
Logic Circuit Development

The logic circuit originally had no timing element to it and used a single eight-leg NAND gate (4011B) to with a two-leg NAND gate (4011B) to create a high output to a buzzer only when all inputs were high. The 4068B chip is not available to me and so I designed an alternative logic circuit to create the same outputs and work in the same way.

AND Gate

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

This design uses seven AND gates (4081B) to produce the same output using available chips.
This is the truth table for an AND gate, it allows a high output only when all eight inputs are high.



This circuit of seven AND gates is very large and uses many different connections from two chips. This would be unnecessarily difficult to build and repair. I simplified the circuit further into a circuit with two four-leg AND gates (4082B) with an AND gate (4011B) connected.

Although this logic is simplified very efficiently, the 4082B chip was unavailable to me.

4-Leg AND Gate

A	B	C	D	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

Counter Circuit Development

Initially this circuit counted digitally using two separate 7 segment displays, the circuit was very large. Some children from the ages of 3-5 may not be able to understand or count numbers up from 0-60, this would mean that they may not have any idea what kind of time limit is on them and therefore not learn as well without good pressure on them.
I have incorporated my chaser circuit in with this design as I feel that the LEDs create a more understandable scale of time than double digits. The LEDs will be very large and stand out a lot on my housing, making them hard for children to miss.

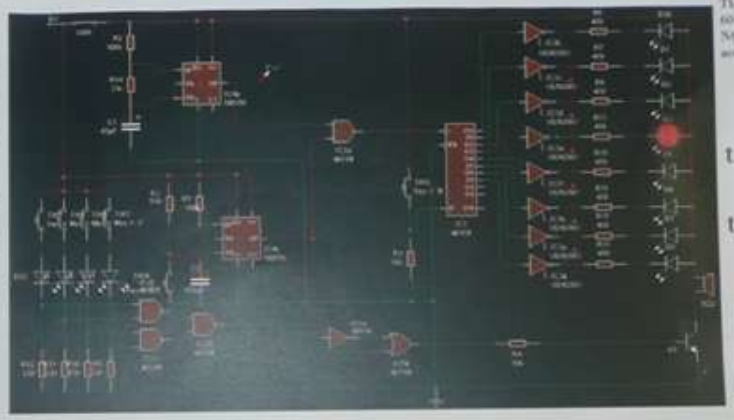
In order to signify the end of the game I have kept the buzzer, the child will know the game has ended when the last LED goes on and the buzzer sounds. I have changed the 555 astable to a single 556 chip which has one monostable half and one astable half in this operation. The astable and monostable are connected to AND gate which will only trigger and input into the clock of the 4017B chip when both inputs are high.
The astable is set to pulse every 6 seconds.

$$f = \frac{1.44}{(R1 + 2R2) \times C}$$

With this formula my count for my astable becomes;

$$F = \frac{1.44}{(100k + 100k) \times 40 \times 10^{-6}} = 0.18$$

$F = 1/t$ $\quad t = 5.8$ seconds



The monostable side of the [illegible] chip is on for 60 seconds, when its output goes low, the NOT logic gate inverts the [illegible] into a 1 and activates the buzzer.

$t = 1.1($ [illegible] $\times 10^{-6})$

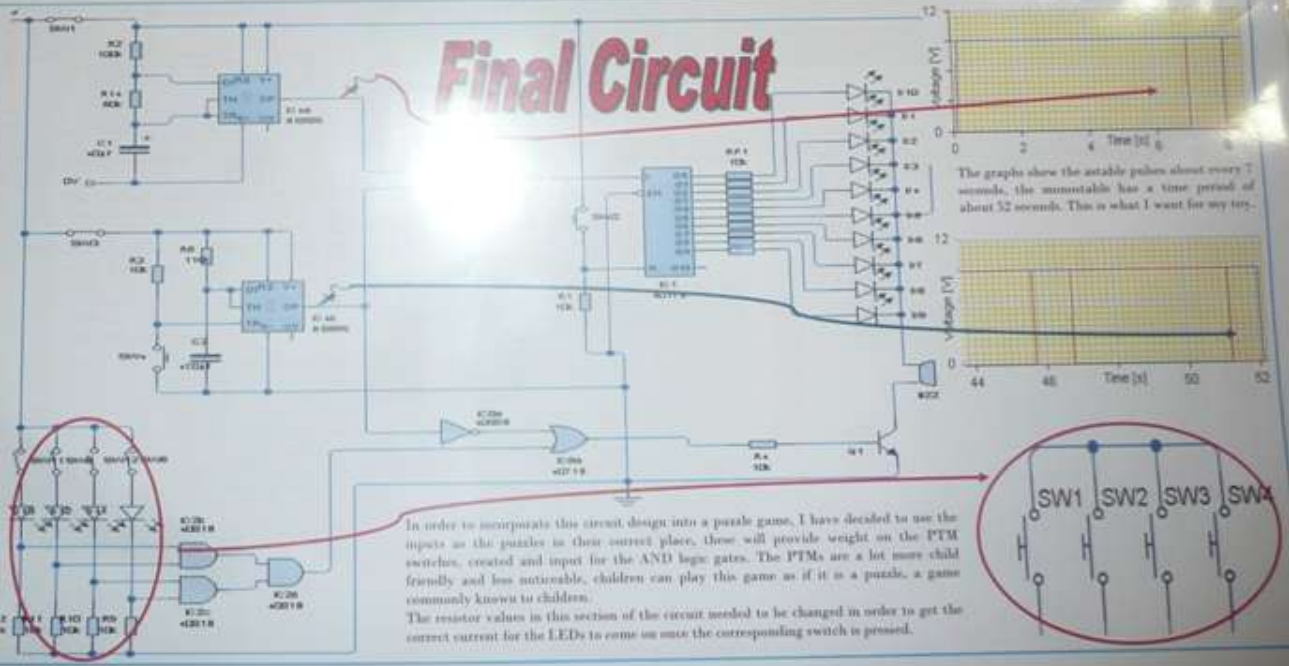
$t = 5($ [illegible]

Circuit Development

I have decided to incorporate all of my three initial circuit designs in together in order to allow the child to get the most out of the toy, both educationally and interactively. I have incorporated the simplified logic circuit into the developed counter circuit in order to give the child inputs to play with and control along side a timer which will count out a time of 60 seconds using a 556 chip. The time element will put the child under a good level of pressure in order to aid them to push themselves and develop their skills of colour and shapes. The logic inputs add an element of fun and interactivity to the toy, the child completes the game if all the inputs are correctly placed before the time runs out.

The 556 monostable output is connected to a NOT logic gate inverter and then into an OR gate. The OR gate has two inputs, one from the inverted output of the 556 monostable set up and also the output of the logic gates circuit which is only high when all inputs are high, is connected into the OR gate along with the inverted monostable output. To signify to the child that the logic gate input is high and had been activated correctly, a green LED is used for each input, lighting when there is a voltage across it.

The buzzer has been connected to the output of the OR gate, meaning that it will be activated through the transistor when either the 60 seconds count from the monostable is up or all the inputs for the logic gates circuit are high. With the buzzer sounding when the game is over along with the last LED being on, the child will know very clearly that the game has finished, either because time is up or the game has been successfully completed.



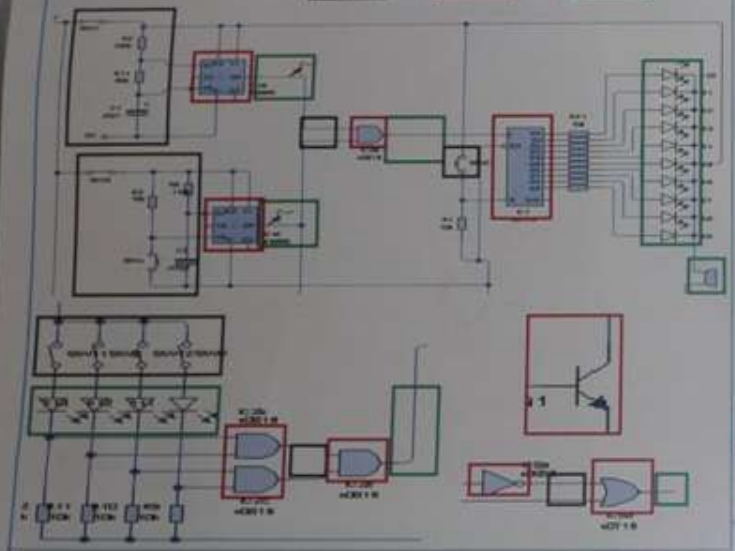
The graphs show the astable pulses about every 7 seconds, the monostable has a time period of about 52 seconds. This is what I want for my toy.

In order to incorporate this circuit design into a puzzle game, I have decided to use the inputs as the puzzles in their correct place, these will provide weight on the PTM switches, created and input for the AND logic gates. The PTMs are a lot more child friendly and less noticeable, children can play this game as if it is a puzzle, a game commonly known to children.
The resistor values in this section of the circuit needed to be changed in order to get the correct current for the LEDs to come on once the corresponding switch is pressed.

Input

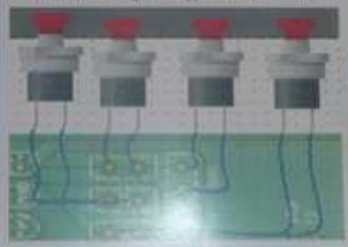
Process

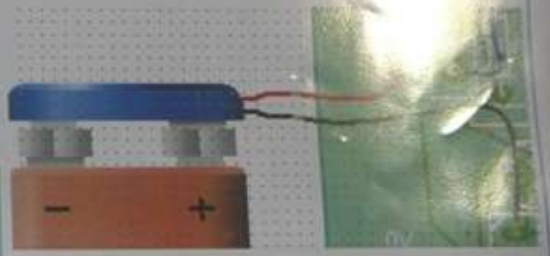
Output



Another way I saved space on my circuit board was to change certain components into off board components, such as LEDs and the Buzzer this meant that there was less room needed on the PCB and it could be reduced in size. I marked the positive leg of the component so I would know which way to wire it up once I [illegible] had to be added to the pin positions to enable the components to be connected. Other than saving space on my [illegible] components to be off board components meant that they could be connected with long wires to enable them to [illegible]

To complete the circuit I needed to complete all connections remaining using flying wires. I also had to add in switches and power supplies where necessary.

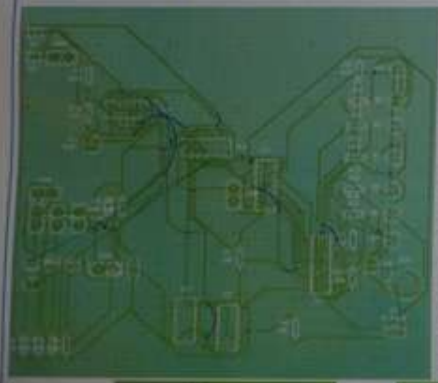




Converting to PCB

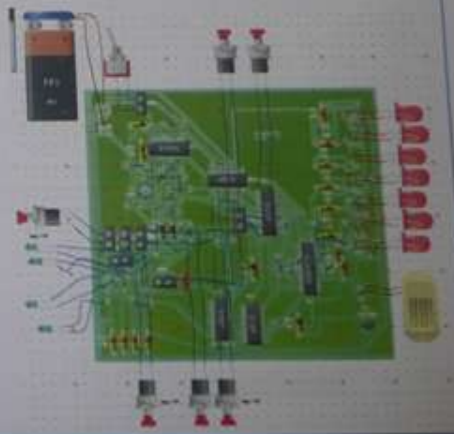
For my circuit to be manufactured I had to first create a printed circuit board for my circuit. The PCB would allow me to create my circuit board on the computer, develop it and make improvements before it was made. I designed the circuit board to make it as small as possible, without loosing any of its efficiency. One of the ways I did this was by using thin copper tracks.

This is what the PCB initially looked like, some of the connections could not be made by the computer and required me to add in copper pads and flying wires, these connections are shown by the light green lines to make the most of the free space and reduce the size down I moved the copper tracks about to enable me to then crop down the edges of the PCB board.

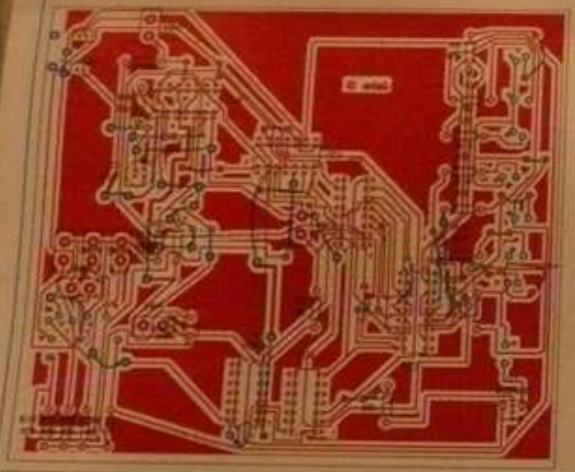


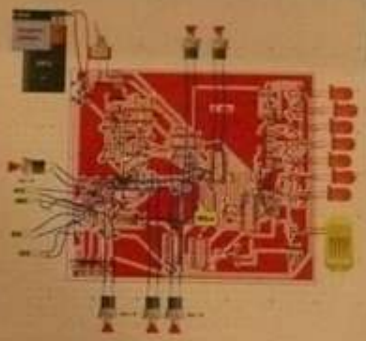
This is my PCB [illegible] changes were made, the circuit needed [illegible] more efficient, safe and reliable

After I tidied up the PCB to ensure the connections could be made easily and to improve reliability this is my finished PCB design with off board components

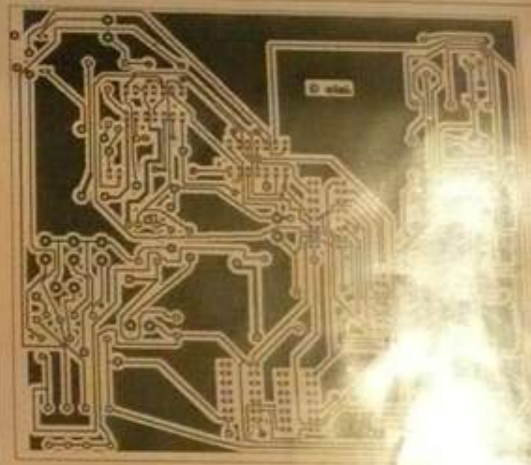


Final PCB Circuit

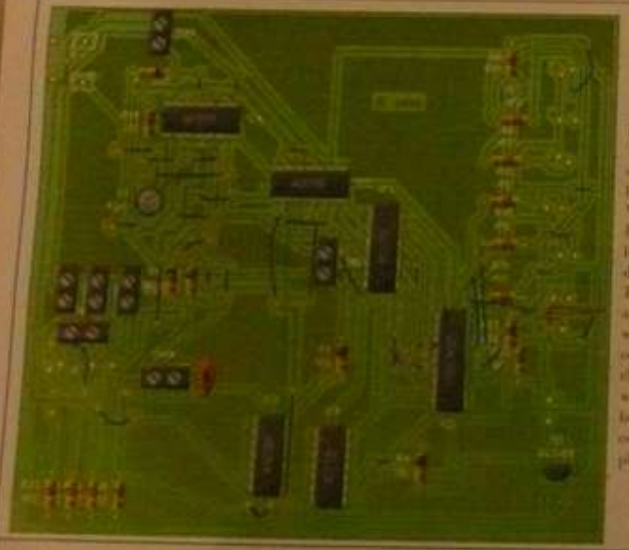




NORMAL VIEW – The normal view allows me to see the pin connections and the copper tracks going through and under chips clearly, this will help me make my circuit once the PCB is printed



ARTWORK VIEW – Artwork view allows me to [illegible] and copper pads only with no components, [illegible] the circuit



REAL WORLD VIEW – This view allows me to see the circuit as it will look when finished. When making my circuit I will check to see if it looks like this PCB design from this view. The real work view allows it to see the PCB with or without off board components. Making it clearer and easier to see where flying wires, off board and on board components are to be placed

Name	Cost	Quantity	Total
100k Resistor (1/4W)	0.20	1	0.20
10k Resistor (1/4W)	0.20	2	0.40
140.24 (W) x 127 (H) mm Printed Circuit Board	10.33	1	10.33
2-pin Terminal Block	0.50	7	0.50
33k Resistor (1/4W)	0.20	1	0.20
40175 Decoded Decade (Divide-by-10) Counter	0.20	1	0.20
40106 Hex Inverter	0.20	1	0.20
4073 Quad 3-input OR Gate	0.20	1	0.20
4081 Quad 2-input AND Gate	0.20	1	0.20
47µF Electrolytic Capacitor	0.20	1	0.20
470 Resistor (1/4W)	0.20	12	0.20
470µF Capacitor	0.20	1	0.20
68k Resistor (1/4W)	0.20	1	0.20
Battery (Ideal)	0.20	1	0.20
BC548B NPN Transistor	0.20	1	0.20
Buzzer (Rectangular)	0.20	1	0.20
Green LED (5.12 in., 3 mm)	0.20	4	0.20
NE555 Dual Bipolar Timer	0.20	1	0.20
Red LED (5.4 in., 10 mm)	0.20	7	0.20
SPST Switch	0.20	1	0.20
ULN2003 Darlington Array	0.20	1	0.20
		Total	15.13

Initial Ideas – Hous

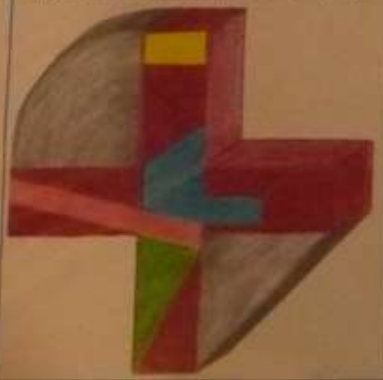
Housing Design 1

:Function
The use of this toy is to complete and finish off the shape of the X by placing shapes provided into the gaps in the X. The storage compartments at the sides of the X shape are very useful for storing the pieces to the jigsaw to be used by the children, ensuring none of it is easily misplaced.
This toy is not big enough to be used along with all of the circuit designs. The LEDs of the chaser circuit could be placed around the edges of the toy going from top to bottom. The small start and stop buttons could be fitted to the top of the toy to be clearly displayed.
The logic current is simple enough to be used with this small housing; the inputs are already there with the puzzle parts. The parts could be placed on PTM switches to create a high input to the eight leg NAND gate.

:Aesthetics / Materials Used
This housing design is shaped like an X which is very unusual but still aesthetically pleasing. The look is improved especially with the use of different types of materials including bright acrylic for the separate parts of the puzzle.
The stainless steel used for the storage compartments is very robust and increases the toys life time. The stainless steel gives a good finish to compliment the quality of the rest of the product.
The mahogany is a very aesthetically pleasing wood which will improve the look of the toy and stop it from looking cheap. The darkness of the mahogany will compliment the acrylic pieces and make them appear very bright and colourful.

:Ergonomics
The housing design has dimensions 350mmX350mmX50mm. Its size and shape means that it could not be easily gripped even by adult sized hands, meaning it is not very portable and would have to be used on a table or on the floor.

:Problems
A seven segment display circuit with start and stop buttons wouldn't fit inside this housing and there would not be enough room for the two seven segment displays being used. This rules out a very good circuit design.
The room needed for any of the circuits is not available within this housing, this means that even if the circuit does fit it would not have the desired room to operate perfectly.
The task designed for the toy is very complicated and may not suit my target age group. If it is too complicated for the children they will put it to one side and not play with it. The children will not enjoy the toy if it is too complicated and thus will not learn or benefit from the toy.



Housing Design 2

:Function
This product challenges children to complete a task along with a race lover. It has a large foam body with two fire engine shapes on either side. There is a section of a jigsaw puzzle to be completed. It has a storage compartment at the bottom and a space for a timer and buttons to be incorporated into the design.
This design works particularly well using either of the counting circuits, with seven segment displays or LEDs. It is large enough to house any of the circuits combinations and also its components, such as large push buttons or 10mm LEDs.
For the chaser circuit the LEDs could run along the top of the fire trucks as eyes from the back to the front of the fire truck.
The space for the start button shown could be used as a power button for any of the circuits, as a toggle switch to connect the circuit to the battery supply.

:Aesthetics / Materials Used
This housing design had a very simplistic design, it would be far too boring to be used if it didn't have the fire trucks either side of it. The
housing in the sense that it is made of pine, a light wood which will help highlight features such as the jigsaw, the counters and the buttons
makes the toy more useable for the age group aimed at, 3-5 year olds.
The fire trucks on either side are made from MDF using a CNC machine. The fire truck will be painted red so that the children will
familiarise themselves with it.

:Ergonomics
This product has dimensions 400mmX205mmX350mm making it a large product, which is heavy due to the amount of materials being used. The weight and shape of this design means that it is not very mobile and it could do a lot of damage if it was pushed off the edge of a table.

:Problems
As the toy looks like a toy truck from one side, children may try to push it about, and they may be disappointed that it doesn't move.
The toy is very large and would be difficult even for a teacher to grab hold of and put onto a high shelf.
The circuit would be very hard to access as there is no opening to get in to work on the circuit.

Housing Design 3

:Function
This design is based on a simple jigsaw puzzle, which is electronically controlled using a timer. It has a large playing surface on the top for a range of different jigsaws to be completed. It has a storage drawer which stores all of the different jigsaw pieces along with room for other toys.

This design is based on a simple jigsaw puzzle, which is electronically controlled using a timer. It has a large playing surface on the top for a range of different jigsaws to be completed. It has a storage drawer which stores all of the different jigsaw pieces along with room for other toys.
The large start button on the side of the housing easily fits along with a buzzer and has the needed space to store any of my circuit ideas. Many components could be added in with ease without affecting the shape of the design at all.
With this toy the child will begin to know that the yellow side is where the storage drawer is, giving them quick and easy access to where the puzzle pieces will be stored. The brass handle on the drawer has a good finish and mixes well with the yellow, along side being aesthetically pleasing the brass handle stops the overall product from looking too cheap.

:Aesthetics / Materials Used
This design is a simple rectangle, although it is not very eye catching with regards to shape, I feel that with the addition of the MDF border around the puzzle surface the sharpness of the corners and the overall look of the design has been softened. The paint coat on the wooden housing makes it brighter and more attractive to children, the use of yellow acrylic for the front of the drawer gives it a good finish and shows the child clearly that this part of the product is separate.

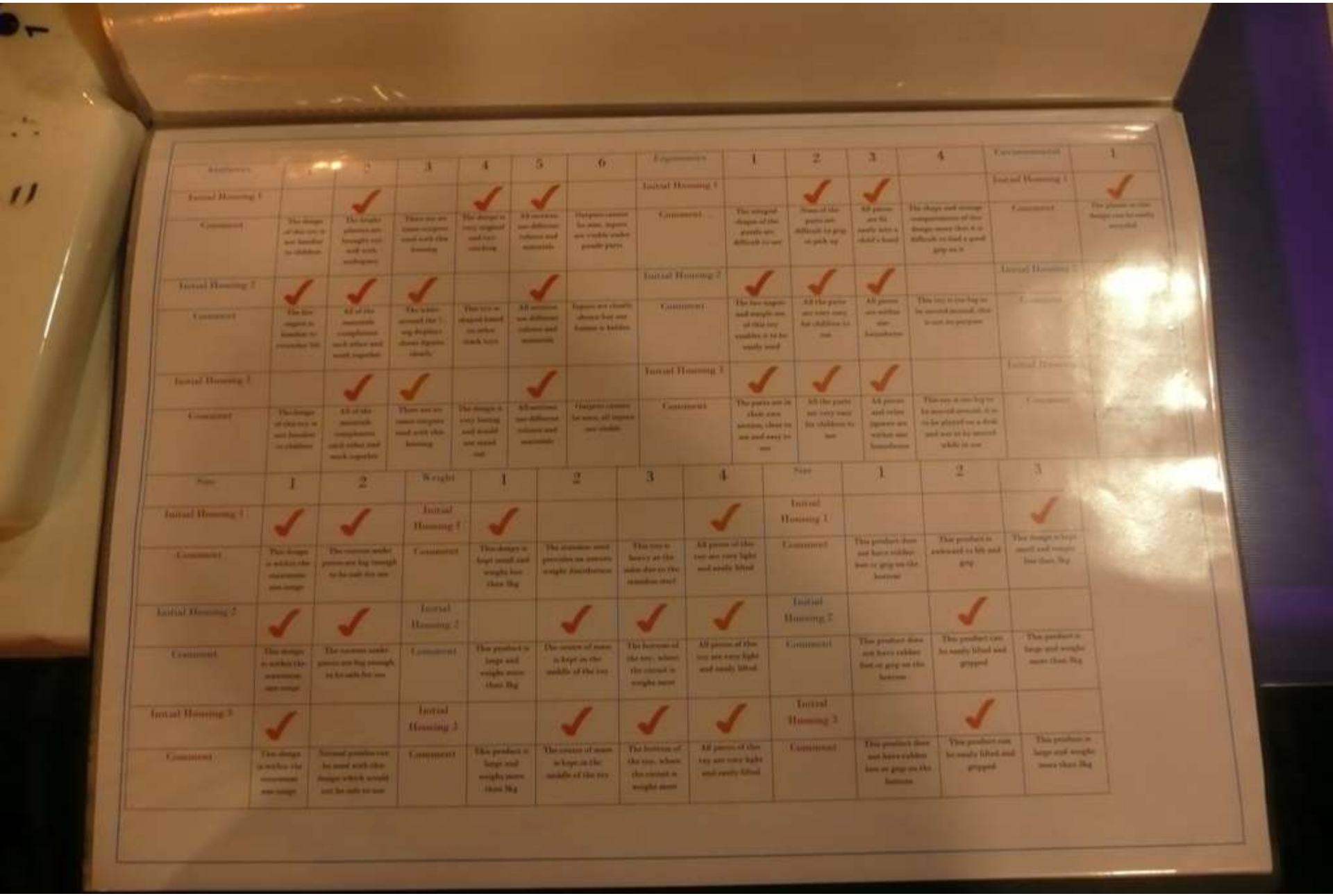
:Ergonomics
This product has 285mmX375mmX125mm so it would be very awkward for even a teacher or adult to try to lift this product comfortably. This product's weight is kept down by the use of light materials such as woods and minimal usage of metals.

:Problems
The draw used is not very stable or strong and could be easily damaged if the product was to be used roughly, young children can be quick rough and careless with toys. Its size in general would make it very difficult to shift and carry about. There would be no problems fitting circuits in, only hiding wires out of sight could be a problem.

Evaluation Against Specification

Function	1	2	3	4	5	6	7	8	9	10	Durability	1
Initial Housing 1			✓	✓			✓	✓	✓		Initial Housing 1	✓
Comment	The task is too difficult as would bore children	This toy only has one puzzle which can't be changed	As the game is difficult it will cause the children need to concentrate a lot	The design incorporates a wide range of colours and unusual shapes	The design is unusual, there is not much sense of fun about it	This design has only one output, a buzzer to sound at end of game	There is a buzzer to sound, controlled by a timing circuit	The game task is timed to take 60 seconds	Buzzer sounds to strike score	The toy only has the jigsaw puzzle	Comment	The components are well protected along with the fun engine shapes
Initial Housing 2	✓	✓	✓	✓	✓		✓	✓			Initial Housing 2	✓
Comment	The fun engine theme gives the user a familiar feel	This toy can be used with any puzzle in the size of the playing area	There is a time limit on this task which will help concentrate the students	There are a wide range of colours and shapes used within the task	This design gives children the sense they are playing	This design has only one output, a buzzer to sound at end of game	There is a buzzer to sound, controlled by a timing circuit	The game task is timed to take 60 seconds	Buzzer only sounds if timing is up	The toy only has the jigsaw puzzle	Comment	The components are well protected along with the fun engine shapes
Initial Housing 3		✓	✓		✓		✓	✓			Initial Housing 3	✓
Comment	The design has a very boring and simple shape	This toy can be used with any puzzle in the size of the playing area	The design includes a large wood puzzle which will be challenging	This toy is to be used for use with everyday puzzles, not teaching colours or shapes well	This task, like all puzzles is enjoyable for children	This design has only one output, a buzzer to sound at end of game	There is a buzzer to sound, controlled by a timing circuit	The game task is timed to take 60 seconds		The toy only has the jigsaw puzzle	Comment	Almost all components are screwed and the housing is very strong

Ease/Inconvenience	1	2	3	4	Materials	1	2	3/4	5	
Initial Housing 1	✓	✓			Initial Housing 1	✓	✓	✓		✓
Comment	This toy is aimed to be used either on the floor or at a desk	This design is small enough to be used with ease by children	The puzzle pieces are custom made for this toy and may be difficult to fit in pursuits	This product is an awkward shape and would be difficult to lift	Comment	This product looks good and has the strength of materials to be very durable	The puzzle pieces are acrylic and very hygienic	There are no sharp edges and all corners are smoothed	The seamless steel and the mahogany are heavy materials	All the moveable puzzle pieces are made using acrylic which is very light and strong
Initial Housing 2	✓		✓	✓	Initial Housing 2	✓	✓	✓	✓	✓
Comment	This toy is to be used at a desk	The fun engine helps convert the child from reaching to the middle of the toy	The toy is easy to use and the task does not strain the child	This design sits level on a floor or desk, can be easily picked up	Comment	This product looks good and has the strength of materials to be very durable	The puzzle pieces are acrylic and very hygienic	There are no sharp edges and all corners are smoothed	The MDF is very light	All the moveable puzzle pieces are made using acrylic which is very light and strong
Initial Housing 3	✓	✓	✓	✓	Initial Housing 3	✓	✓			✓
Comment	A table or desk is necessary in order to support the toy	The toy is very large and small children may find it difficult to reach across	The toy is easy to use and the task does not strain the child	This design sits level on a floor or desk, can be easily picked up	Comment	This product looks good and has the strength of materials to be very durable	The puzzle pieces are acrylic and very hygienic	This design has a few wood screw countable to splinters	The plastic and the unusual drawers are heavy materials	All the moveable puzzle pieces are made using acrylic which is very light and strong



Initial Housings – Choice For Development

Function	1	2/3	4	5	6
Initial Housing 1	✓	✓	✓	✓	✓
Comment	This product is well protected by steel and its solid shape	The custom make pieces are big enough to be safe for use	The internal circuit, including wires and process components are not visible to touch	The battery is only accessible to teachers using a screwdriver	All wires will be covered correctly for maximum safety
Initial Housing 2	✓	✓	✓	✓	✓
Comment	This design makes use of very strong materials to ensure safety	The custom make pieces are big enough to be safe for use	The internal circuit, including wires and process components are not visible to touch	The battery is only accessible to teachers using a screwdriver	All wires will be covered correctly for maximum safety
Initial Housing 3	✓		✓		✓
Comment	If this design were to be used outdoors, the circuit is not protected well enough	Normal puzzles can be used with this design which would not be safe to use	The internal circuit, including wires and process components are not visible to touch	The bottom of the design housing is not covered and children could easily get in and touch the battery	All wires will be covered correctly for maximum safety

	TOTAL SCORE
Initial Housing 1	30
Initial Housing 2	37
Initial Housing 3	28

The design that I have chose to develop from my initial housing design is my initial housing 2. The reasons for this choice include, it scored the highest score out of the 3 initial housings in my evaluation. Another reason for my choice is that I feel the initial housing 2 design has a lot of potential to develop good qualities to make it an almost perfect design.

This is my chosen initial housing to develop - it is already a very good design but can be developed into a brilliant product

Development – Housing

Choice of Housing

The initial housing that I am going to improve and develop into my final design is my second housing design, 'housing design 2'. The reasons for deciding to develop that housing design include how child friendly it already is, how spacious it is and also the wide range of colours that can be incorporated into it. The design is already very child friendly, but despite this it has areas for improvement.

Improvement 1

The initial design for this housing was very heavy and could not be easily moved around by a small child. In order to make this design more moveable and fun overall, I have decided to add rubber wheels to the design so that the product can be moved about as a pulley toy or used as a jigsaw like in the initial design.

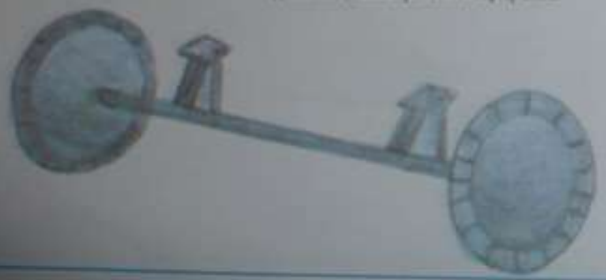
Wheel Design 1

This design of wheel has four wheels all on separate swivel connections to the bottom of the design. This means that the wheels can move in any direction, with each wheel moving separately that toy can be made to turn in circles and is not restricted to straight lines. With added movement to the toy with separate connections the wheels are very unstable and can easily break. If one wheel breaks the toy can't be used as a pulley and even stationary the toy is unstable. With the wheels being attached using screws to the bottom of the toy, the overall height of the toy will be increased, disrupting the shape and feel of the toy.

Wheel Design 2

Another option for the wheels is to have the front and back sets both on two axels, meaning the toy is very steady and the wheels are less likely to be damaged. The disadvantage of having the wheels stuck in one direction is that the toy can't be moved around the floor, only rolled back and fourth. The toy will be more secure and sturdy, meaning it will have a longer life when used in a harsh classroom environment.

For these reasons I have chose to use my second wheel design as the toy is mainly used for educational purposes and the movement is less important that the stability and safety of the toy. The wheels will need to be at least 100mm in diameter to support the toy and keep the looks in proportion.



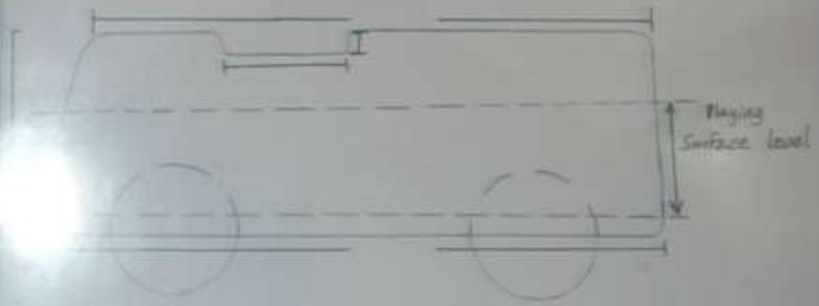
Improvement 2

I feel that the size of this design is very large, a lot bigger than is needs to be. The children using it may feel it difficult or unnecessarily difficult to move about because of its sheer size. There is nowhere to get a good grip on the toy to push it along the floor or to lift it.

To improve the design I have minimised the size and shape of the toy and also added a groove into the top of the track for better grip. As a result of these changes the look of the toy is greatly improved as it has better proportions to its user and the 'M10' at the sides looks more like a fire engine.

With the new design the toy can be easily handled by adults and easily pushed around the floor by children. If the design was smaller a young child would be able to lift it up and cause damage to themselves or others, this is why I have kept a good amount of size to the toy.

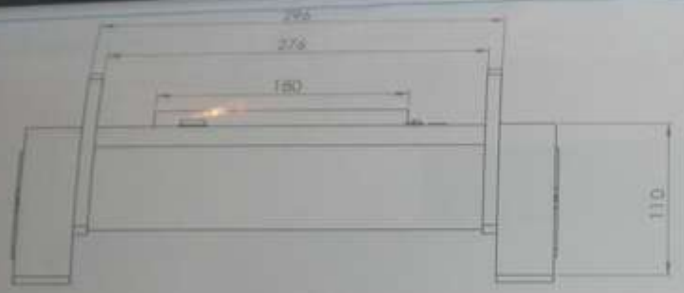
Space for the wheels to be incorporated can be cut out as shown here on this side profile of my final housing. This ensures that the wheels fit securely into and are protected by the housing.

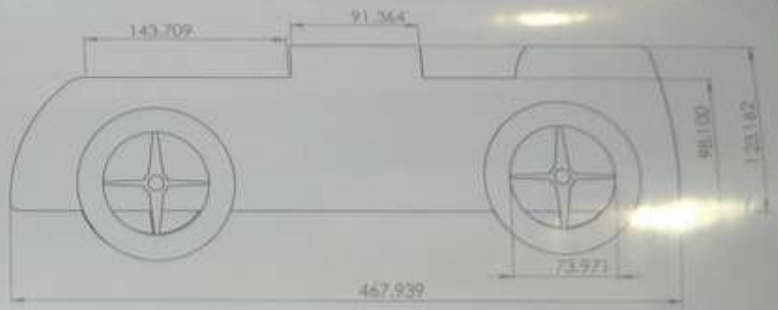


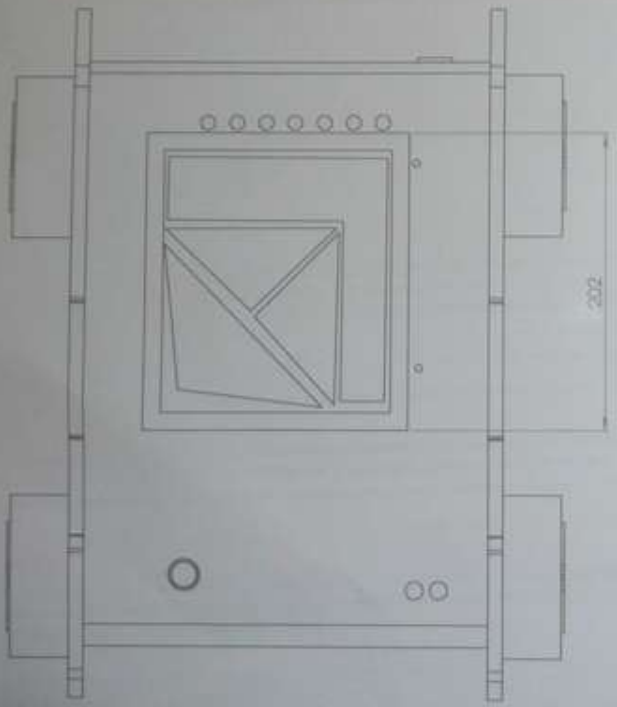
Choice Of Wheel

The wheels for this toy had to be strong and mobile, the wheels must easily be fitted to axles to stretch across the whole toy and create a strong element of support for the toys weight to rest on. The rubber tires around the plastic will give the toy added grip on all playing surfaces.

The wide diameter of the wheels enable good balance and mobility of the product. The wheels have diameters 40X40X110 which fits well into my design.







Educational Toy	Scale 1:275
Candidate Number : 4035	Centre Number : 71271

Plan For Manufacture

Week 1+2

Materials + Features - This will include designing and deciding on what three materials I will be using for my product, each having to serve its own useful purpose. The features making this game exciting must be chosen carefully in order to improve the quality of the toy as a learning device.

Week 3

Design Main Shape and Space for Input / Output Components - The shape of the design must be ergonomic and research on similar products should be carried out in order to obtain general sizes and styles of successful educational toys. The placement of input and output components that the user will interact with needs to be designed around making the game as easy for young children to play as possible.

Week 4

Cut Out and Glue Main Housing Together - The manufacturing must be accurate and the main housing needs to be strong and durable in order to support the circuit and the rest of the housing. The glue needs to be left to set for 24 hours.

Week 4+5

Design Circuit - Work on the computer with circuit wizard designing a suitable circuit containing all my needed functions with the simplest of inputs. Circuits should be made up using existing circuits and ideas from resources, the circuit will be manipulated in order to perform the needed tasks.

Week 5

Convert Circuit to PCB - The designed circuit will be converted into PCB layout on circuit wizard, the circuit will be tidied up to ensure efficiency and maximum safety. The circuit will then be printed onto a circuit board.

Week 7+8

Paint Housing + Cut Acrylic Jigsaw Pieces - The primed housing given a single coat of enamel paint to give a good shiny, smooth finish. The pieces of acrylic needed for the jigsaw must be cut out, using a variety of bright colours, the four pieces of acrylic must make up a rectangle.

Week 7+8

Solder Components into PCB - The all board components and the soldered components must be soldered into the PCB too, [illegible] components must be connected using long flying wires in order to reach their desired place within the housing. Flying wires connecting disconnected parts of the circuit must be made.

Week 9

Place Circuit into Housing - The space for the housing within the circuit must be made and the circuit must fit snugly with no room for it to move about and cause damage to itself. The casing for the circuit must not put strain on any of the connections.

Week 9

Finish Acrylic - The puzzle pieces must be filed down so that they fit in well together with no gaps or pressure on any individual piece, the edges need to be smoothed down as these pieces are the part of the toy that are going to be used most by children.

Week 9+10

Test Product + Against Specification - All relevant and necessary tests must be carried out on the housing and circuit individually to ensure it is of quality and safety to be used by young children in a school for children with disabilities. The product must be viewed overall and tested against the original specification to tick off what was met and what could be improved on.

Testing

The logic input PTMs cause the green LEDs to go on when each of them is pressed to indicate that section of the puzzle is complete. Here the LED has went on due to the puzzle piece being correctly placed

The start button is easily pressed to trigger the count and reset the red LEDs. The power button must connect and quickly disconnect the whole circuit to the battery

All the wires for the circuit are hidden within the housing and are not in sight or reach of children

The buzzer is able to be heard when the count completes from a distance of 10m away at least

The green and red LEDs are clear and bright to be easily seen, even in light conditions. Here the red LEDs are in mid counting sequence

The wheels sit flat enough so that the housing is steady when the puzzle is being played and it does not wobble about everywhere

Modifications During Manufacture

Wheel Axle

The first change I had to make during manufacture was the material for the wheel axles. Oragnally I had decided to make the axels out of steel giving the wheels good support and strength.
I had to change the material to PVC as there was no steel rods in the diameter I needed available to me. I ensured that the PVC was suitable for the product before I used it

Oak Frame

The puzzle area where the task was to be performed was never clear in my initial designs or after my development. When I began to design my product I noticed this error, it would be hard for children to see what shape to make out of the puzzle pieces and where to put them. In order to fix this problem I designed an oak frame to be placed around where the puzzle pieces were to be placed, in the shape of what was supposed to be created by the puzzle pieces. The oak was varnished and then sanded down to give it a very nice look without taking away from the bright acrylic of the puzzle pieces

Future Modifications

Push Buttons For Puzzle Inputs

The problem with the puzzle inputs to be triggered by the puzzle pieces occurred because of the weight of the acrylic used. The acrylic was not heavy enough to push down the button every time, to fix this problem in the future I would use more sensitive PTM switches which are easily triggered

Size

The overall size of the product looks disproportional when the LEDs are placed in it. In the future I would either scale the housing down or used bigger LEDs, enabling the aesthetics of the product to increase above its already high level

Push Buttons For Resets

The two reset buttons for the count of the numerable [illegible] and the ULN2803 both need to be pressed together, this can be achieved by attaching a single block of plastic above both push buttons. The plastic piece would say push on it.

Final Evaluation Against Specification

I will evaluate my final design in the three most important fields needed for a quality child's educational toy. The chosen fields to be examined are; Function, Aesthetics and the circuit quality

Function

1. The toy is simple but exciting, enabling students to perform the task but still want to improve on their skills

2. There is only one level of game difficulty, although the more puzzle pieces of the correct sizes could be used on the puzzle playing surface of the toy

3. The game is of a very good level of difficulty, children will not be bored by this either because of the effort needed not being too little or too much

4/5. This game will teach the students how to learn their colours and shapes, the students will also learn how to find a good balance between work and play

6. The toy gives out very clear indicators to how close to the completion of the task the student is, also the timing element is clearly shown by LEDs

7. The time limit of this task is not clearly displayed before the student uses the toy. When played, the user can clearly see how much time there is is left and also the outputs make it clear to the student that the game is over

8. There is a time limit on the toy of 60 seconds

9. The buzzer sound if either the time is up or the game has been completed

10. The product is also a pulley toy that can be easily moved about the floor, the toy resembles a fire engine which is a fun and exiting shape for children to see

Circuit

1. The circuit easily fits into my housing, the space give protection for components and increases the circuit durability

2. I have used bright colours, large push buttons and toggle switches on my circuit to enable easy use by children

3. Children with very strong hearing or sight difficulties may struggle to notice the outputs of when [illegible] so in this case the child may have an assistant whom can aid them in completing the task

4. The circuit runs a logic function for the task alongside a timing function, these are linked by an OR logic gate

5. When the timer counts down from one minute, the count end is shown using a buzzer, telling the user the time is up, this is also indicated by the last red LED turning off

6. The circuit is well manufactured, no wires are in reach of the children using the toy and present no harm or danger to any user

7. The circuit has its own cover under the housing and is protected from all areas within its casing

8. For maintenance reasons the circuit can be accessed by unscrewing the bottom of the housing casing. Removal of the casing cover gives the professional technician a view of the PCB circuit

9. The battery is connected [illegible] battery clip, this enables the old battery to be easily removed and replaced with a new battery to keep the toy available for all [illegible]

Aesthetics

1. I have used the theme of 'Fireman Sam', putting the shape of his fire engine on each side of my design will allow the children to familiarise themselves and be comfortable with the product

2. There are a wide range of colours and shapes used within the housing of the toy which will help grab the attention of children

3. The main housing is white; this draws attention to all of the different parts of the housing

4. I have curved the edges of the housing, along with the oak boarder around the task area and the fire engine sides alongside the product this toy will not fade away into the background

5. There is not clear indication as to what colours are to be placed where. I feel that over time the children will familiarise themselves with the layout of the finished task, enabling them to carry out the task from memory. This will greatly improve their colour memory as they are using both the memory of the colour of the pieces along with their shape and where they are to be placed

6. The buttons and LEDs used are very clear to see, along with the buzzer no children will have trouble understanding how this simple toy works


POST MATE
ROE VALLEY FENCING