



University of
Hertfordshire

Logbook

Integrated Industrial
Experience EA2

MATTHEW HARRISON EE1

Group
67

PROJECT - AN OVERVIEW

During Semester A of the first year BEng (Hons) Engineering Design and Communications course a Group Design Project will be undertaken (EA1). In Semester B the design will be manufactured during the time allocated to the Engineering Applications Activity (EA2). In both Semesters working in groups entails cooperation and teamwork and emphasis will be placed upon these qualities.

This Logbook is provided to document the EA2 activity.

ENGINEERING DESIGN PROJECT - INTRODUCTION

Design is a multi-disciplinary activity covering both technical and non-technical areas. Decisions made in isolation often lead to the formation of problems that if left undiscovered will result in extending the product lead time and incur additional costs.

The objective of this design exercise is to experience the design processes from concept to producing a manufactured product. A preliminary specification sheet contains general basic information to enable you to carry out the task. Such information includes a customer specification from which you may derive a Product Design Specification (PDS). Design should be a closed loop activity with the PDS acting as a core and also the basis upon which your final chosen design and hence manufactured product, should be tested against.

THE PROJECT BRIEF

Product:- *Digital Torque Wrench*

Customer requirements are:-

- capable of applying a torque of up to 60Nm at the drive
- the display to have three separate LED's each measuring 7.5 x 13 x 6mm deep (3 units side by side will measure 22.5 x 13 x 6mm). Digital display value between 0 and 999
- a choice of power supply: either a single 9v battery type PP3 or 4-AAA batteries requiring a holder to be designed and manufactured.
- power to be manually activated by a PCB mounted on/off switch
- maximum overall length of wrench not to exceed 350mm
- design must be able to accommodate a printed circuit board measuring 120 x 21 x 12mm deep
- wrench for use in a garage environment by a typical adult for tightening standard left and right-hand threaded nuts/bolts
- wrench to be fitted with a 1/2 inch drive suitable for a standard range of sockets
- all aspects of the load transducer and digital display need to be waterproof
- specification for the strain gauge upon which the torque transducer design will be based is as follows:-
 - gauge dimensions 8 x 2mm
 - gauge resistance 120 Ω + or - 0.5%
 - gauge factor 2.1 + or - 1% (temp coeff $\leq$ 5%/100 °C)
 - temperature compensated for mild steel
 - supplied fitted with 30mm flying leads
- discrete area available for operator to grip wrench when applying the torque load
- wrench should conform to BS EN26789
- a metal fabricated case complete with vacuum formed insert suitable for accommodating the wrench to be included

NB a ratchet device is not required.

THE MANUFACTURING STAGE

The following pages are a record of the processes carried out in the manufacture of your group design and should document your experiences and observations and be written in the style of 'third person past tense'.

What information do I record?

Whilst engaged in each activity, notes should be taken of:-

1. The manufacturing process - techniques/equipment
2. Testing and measuring techniques
3. Tooling
4. Handling/clamping devices
5. Materials used
6. SAFETY CONSIDERATIONS

How should I illustrate my report?

A neat sketch or machine drawing of a component being discussed should be included adjacent to the written information and be drawn directly onto the graph sheet(s).

P J Lumkin
EA2 Course Tutor

Electronic Design

Week 1 : Circuit Prototyping

1.1 Task 1 : Use of Proto board

* Equipment Used

- 1 Wire cutters
- 1 Small pliers
- 1 Bread board (Proto board)
- 1 $10\mu\text{F}$ capacitor
- 1 $0.1\mu\text{F}$ capacitor
- 2 Standard LED's
- 1 8-Pin D.I.L 555 TIMER
- 2 $1\text{k}\Omega$ Resistors (calculations shown latter) *
- 1 $8\text{k}\Omega$ Resistor (calculations shown latter) **
- 1 $68\text{k}\Omega$ Resistor (" " ") ***

Calculations

$$\text{Frequency} \approx 1.44 / (R_T \times C_1)$$

$$t_2 \approx 0.7 (R_2 \times C_1)$$

$$R_T \approx (R_1 + 2R_2)$$

$$\begin{array}{lcl} \text{Frequency} = 1\text{Hz} & \Rightarrow & 1\text{Hz} = \frac{1.44}{(R_T \times C_1)} \\ C_1 = 10\mu\text{F} & & \end{array}$$

$$\text{SO } R_T = \frac{1.44}{10 \times 10^{-6}} = \underline{144\text{k}\Omega}$$

Find R_2 using $(t_2 = 0.7(R_2 \times C_1))$

$$T = \frac{1}{f} \Rightarrow T = \frac{1}{142} = 1s$$
$$T_2 = \frac{1}{2}T = 0.5s$$

$$R_2 \times 10 \times 10^{-6} = \frac{0.5}{0.7}$$

$$\Rightarrow R_2 = \frac{0.71428}{10 \times 10^{-6}} \Rightarrow 71.428 k\Omega$$

nearest in stock = 68 k Ω ***

Find R_1 using $(R_T = R_1 + 2R_2)$

$$R_1 = R_T - 2R_2$$

$$R_1 = 144000 - 2(68000)$$

$$R_1 = 8 k\Omega \quad \text{nearest in stock} = 8.2 k\Omega \quad **$$

Calculations for R_3 and R_4

$$R_3 = R_4 = \text{Supply Voltage} / \text{LED forward current}$$

$$\text{Supply Voltage} = 10V$$

$$\text{LED Forward current} = 10 \text{ mA} \quad (\text{Was taken from RS Catalogue}$$

March/June 1995:-

LED 590446)

$$R_3 = R_4 = \frac{10V}{10 \times 10^{-3}} = 1 k\Omega$$

$$R_3 = 1 k\Omega \quad *$$

$$R_4 = 1 k\Omega \quad *$$

Next I built the astable 555 circuit (as shown in figure 1) neatly on a protoboard using the equipment stated in the "Equipment used" list.

After building the circuit I plugged the protoboard into a power supply set at 10V and I get a 1Hz output. The LEDs flashed synchronously with about 0.5s between each separate flash.

(A)

Illustration

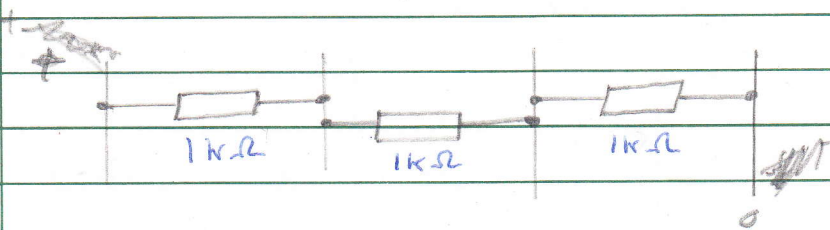
1.2 Task 2: Soldering Exercise

Equipment used

3 x 1 k Ω Resistor	(Brown / Black / red / gold)
1 x 180 k Ω Resistor	(Brown / Grey / yellow / gold)
1 x 150 k Ω Resistor	(Brown / Green / yellow / gold)
1 x 27 k Ω Resistor	(red / violet / orange / gold)
Solder	
1 piece of Vero board	

Resistor Method + Calculation

Placed 3 resistors in series and soldered them to the Vero board.

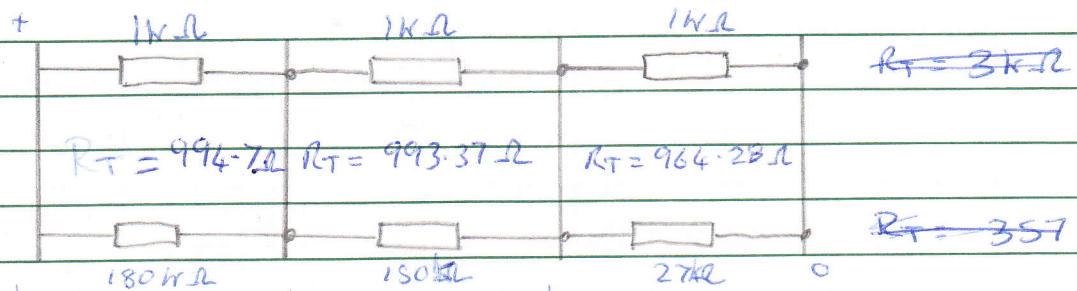


$$R_T = 1 + 1 + 1 \Rightarrow 3k\Omega$$

Measured resistors in series using Multimeter

$$\text{measured } R_T = 2.94 k\Omega$$

1 Then placed 3 more resistors in parallel with the first set and soldered them to the Vero board



$$\frac{1}{R_T} = \frac{1}{1k} + \frac{1}{180k} \quad \frac{1}{R_T} = \frac{1}{1k} + \frac{1}{150k} \quad \frac{1}{R_T} = \frac{1}{1k} + \frac{1}{27k}$$

$$\frac{1}{R_T} = \frac{1}{3k\Omega} + \frac{1}{357k\Omega} \quad R_T = 994.7\Omega + 993.37 + 964.28\Omega$$

$$\frac{1}{R_T} = \frac{40}{119}$$

$$R_T = \cancel{2.975k\Omega} \quad 2.952k\Omega$$

Measured the resistor using the multimeter

$$\text{measured } R_T = 2.906k\Omega$$

ADD

1.3

Task 3 : Construction of SSS timer circuit on a PCB.

Equipment used

- 1 10μF Capacitor
- 1 0.01μF Capacitor
- 2 1kΩ Resistors
- 1 68kΩ Resistor
- 1 8.2kΩ Resistor
- 1 8 PIN D.I.L SSS Timer
- 2 Standard LEDs
- 1 SSS Timer socket
- 1 9V Battery clip
- 1 PCB
- solder
- soldering iron

Next I populated the PCB using the components that I had assembled on my protoboard.

Once I had soldered all the components in, I then tested it, and found that the circuit board did not work. This was because ~~the~~ the capacitor symbol had been incorrectly printed on the circuit board. I then turned the capacitor round and found that it worked correctly. The LEDs flashed synchronously with each other with a gap of approximately 0.5 the flashes of each LED.

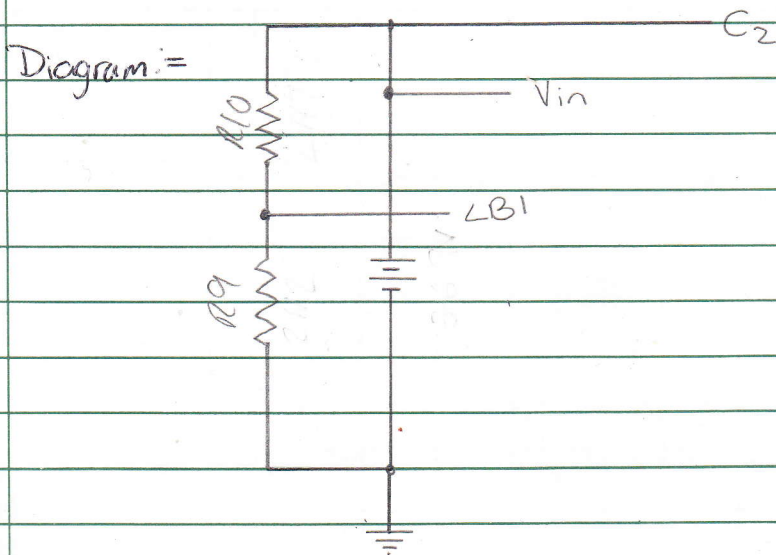
A3Dm

Unit 2 Electronic Torque wrench module.

Task 4.

2.3 Module Assembly.

Task = calculate suitable resistors for the low battery detection circuitry.



Calculations:-

$$R_{10} = R_9 \times (V_{\text{Low}} / 1.3 - 1)$$

V_{Low} = Low Voltage Threshold

$$R_{10} = \cancel{39} \times (\cancel{4.0} / 1.3 - 1)$$

$$\cancel{R_{10} = 86 = 47 \times (\frac{V_{\text{Low}}}{1.3} - 1)}$$

$$R_{10} = 39 \times 2.08$$

$$R_{10} = 81.12 \Omega$$

$$\cancel{(\frac{82}{33} + 1) \times 1.3 = V_{\text{Low}}}$$

$$R_{10} + R_9 = +100 \text{ k}$$

$$81.12 + 39 = 120.12 \text{ k}\Omega$$

This calculation was wrong as the V_{Low} was too small and needed to be around 4.5V instead of 4.0V. So we recalculated it using R_{10} as 82 Ω and R_9 as 33 Ω and got a V_{Low} of:

$$\left(\frac{R_{10}}{R_9} + 1 \right) \times 1.3 = V_{\text{Low}}$$

$$\left(\frac{82}{33} + 1 \right) \times 1.3 = V_{\text{Low}}$$

$$(3.48) \times 1.3 = 4.53 \text{ V}$$

AKD

2.3.2 Component Assembly.

First we carefully identified each component in the kit ~~and~~ using the list in the Appendices. We then placed each component in its relevant place, without soldering it in position.

Used Resistor colour codes in appendix 3 to work out the resistor values.

A5Dn

2.4 The components were soldered carefully to the PCB.

2.4.1 Visual inspection was carried out using a magnifying glass. All soldering was checked that it was ok and there were not any short circuits, all pins soldered, and the components mounted correctly. This check was carried out twice to be double sure everything was in order.

2.4.2 Short circuit test was carried out by using an ammeter connected across JP2 + and - terminals. The meter measured $113.5\text{ k}\Omega$ which showed there was no short circuit in the circuit.

2.4.3 The power supply was set up to 9V and 100mA.

With out placing IC chips in there sockets, we tested pin 8 of U2 and got an output of 9 volts. We then ~~the~~ Place the U2 chip in to its socket and tested pin 2 of that chip and got an output of 5 volts. We then tested pin 20 of U1 and got an output on the multimeter of 5 volts. and finally tested pin 16 of U3 and that also had an output of 5 volts.

These results determined that the circuit was fully operational. The circuit also drew ^{virtually} no current.

A6D

2.5.2 Programming the micro controller

The microcontroller was programmed with the file `n:\eal\code\test00\test00.hex`.

All three chips were placed in their relevant sockets. The power supply was connected to JP2 ~~and~~ ^{which} gave an input of 9V to the circuit.

Then the board beep twice and the display began counting, we then pressed SW2 (set button) and it produced a continuous tone and reset the counter to zero. So we had no faults.

The computer language was C and the compiler C51 was very quick and it saved a lot of time. The test program test 00 determined the working of display and sound.

A7D

2.6 Test 01

The microcontroller was programmed with the file `n:\eal\code\test00\test00.hex`.

We replaced chip U1 and then applied the power to the circuit. Pressed SW1 (ON/OFF) to power the up the module. The board beeped twice and the display showed 999. Slowly we reduced the voltage on the PSU until the 'bat' message appeared. The 'bat' message appeared at about 4.6V which was 0.07V out on what we had calculated.

We then ~~set~~ calibrated the module, to do this

we turned off the power supply and then placed a 120Ω resistor across JPI. We then switch on the power supply and the display showed ~~9.99~~ 9.99 indicating value out of range. We then turned the screw on R4 anti-clockwise until the value ~~9.99~~ went down to 000. The input signal was now calibrated.

A8
Alkhan

2.7 Final calibration of the wrench

mass	Displayed Value	Distance	
Shrg	28 kg	20 cm	extension
Shrg	15 kg	20 cm	compression

$$M_{\text{extend}} = \frac{10}{28} \times 1000 \Rightarrow 357$$

$$M_{\text{Compression}} = \frac{10}{15} \times 1000 \Rightarrow 667$$

We calculated the values of M_{extend} and M_{compress} (as above) and placed the values into the program in directory

n:\real\code\Final

After this we reloaded the program onto the chip.

After the calibration we put the strain gauge

on the wrench module and then retested it for extension and compression values. We got 10 Nm extension at 20cm and 10 Nm compression ~~at~~ also at 20cm.

As
Attachment

FABRICATION

Lesson 1

The lesson began with an introductory talk, where the Lecturer told us about all the aspects of working in a lab. They were:

1) Safety

We were told about how we must always wear goggles and tech coats in the designated areas of the workshop. We were also told where the emergency stop buttons and fire exits were.

2) Machine operation

The Lecturer went through a demonstration of how to make the main part of our torque wrench case, while at the same time showing us how to operate each of the machines in the lab.

3 equipment

We ~~were~~^{where} told to get the equipment that we may need (like emery paper, rules, files, etc) from the equipment store. When getting equipment we had to state our group number, so that the tech knew who had what.

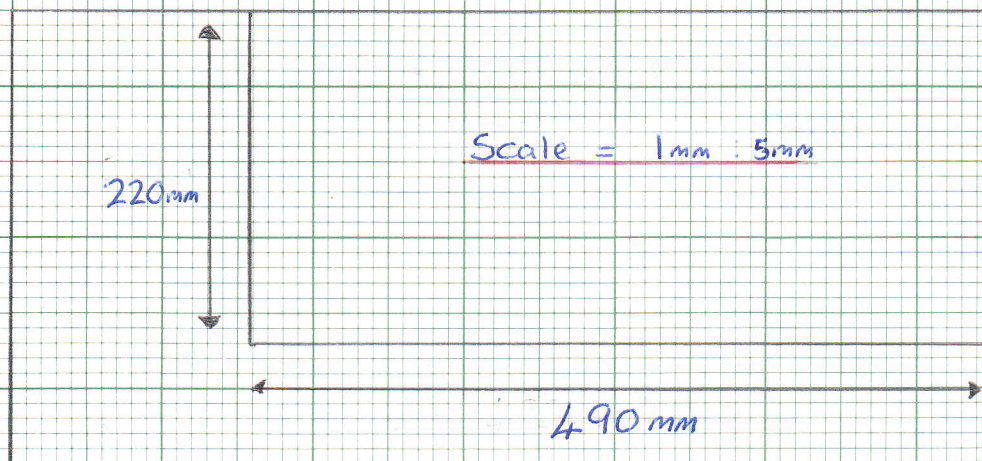


Diagram F1.

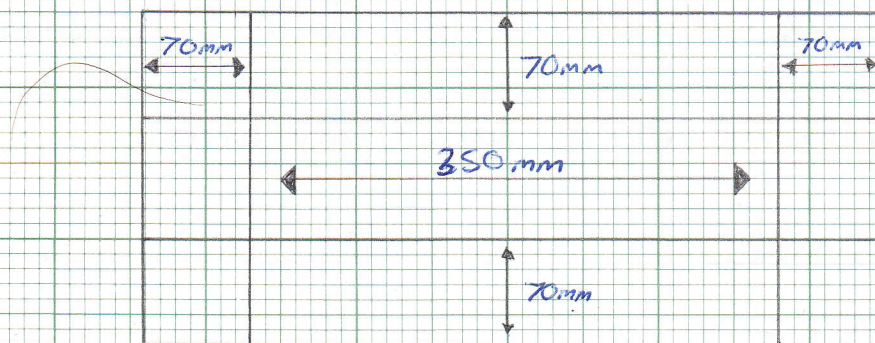


Diagram F2.

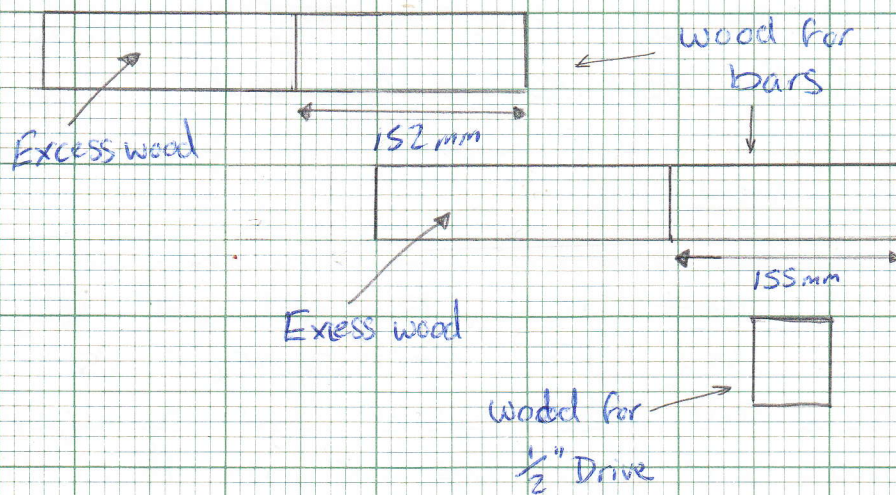
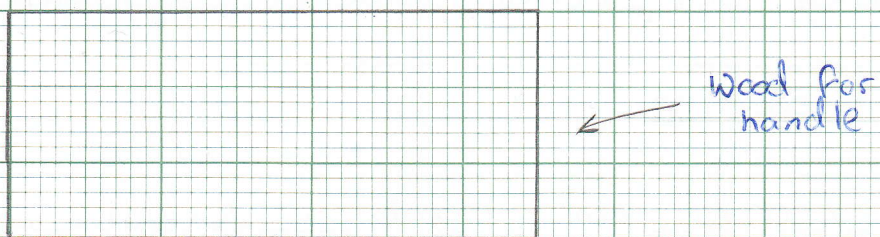


Diagram F3

After the introduction we ~~were~~^{were} given the go ahead to start on our cases. Unfortunately our group did not design a case, so we had a brief discussion ~~on~~ how we wanted the case to look and then did a quick sketch. Then, having worked out the main measurements, we split into two groups - me on the main case and gulmaz and Lee on the vacuum formed inlay. Our fourth member ~~failed~~ failed to show.

The case

I started by getting a piece of ^{mild steel sheet} ~~metal~~, 1.2mm thick, and covering it in marking ink. Taking the measurements from the sketch, which the group had drawn, I measured and marked the required amount of metal needed (see diagram F1). Then using the Guillotine I chopped off the excess metal.

After removing the excess metal, I took the main piece of metal, and measured and marked the main dimensions for the box on it (see diagram F2).

The lesson then ended.

Vacuum Forming

A mold for the digital torque wrench had to be made. To make the mould we had to make a model of the torque wrench out of wood. To do this we got 4 pieces of wood, which were to be made into each separate part of the torque wrench as shown in diagram F3.

■ The wood needed for the $\frac{1}{2}$ " Drive and the 2 bars was available, Unfortunately the wood for the 20mm (radius) Handle was not available.

We took one of the pieces of wood for the bar and measured it to 155mm in length, then using the band saw we chopped off the remaining wood. Then taking the second piece of wood, we measured it to 152mm in length and then chopped off the remaining wood using the bandsaw.

The lesson then ended.

Scale 1mm : 5mm

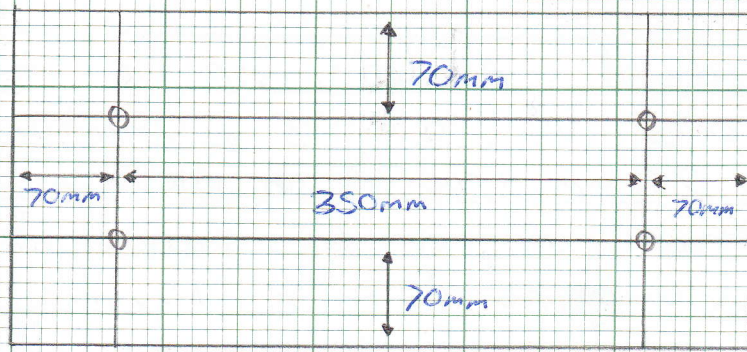


Diagram F4.

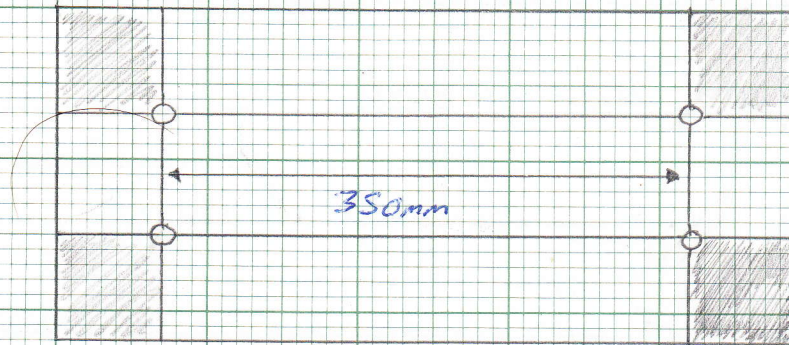


Diagram F5.

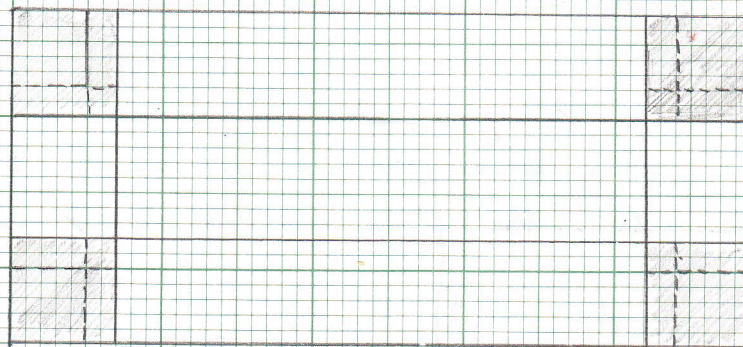


Diagram F6.

Scale 1mm : 2.5mm

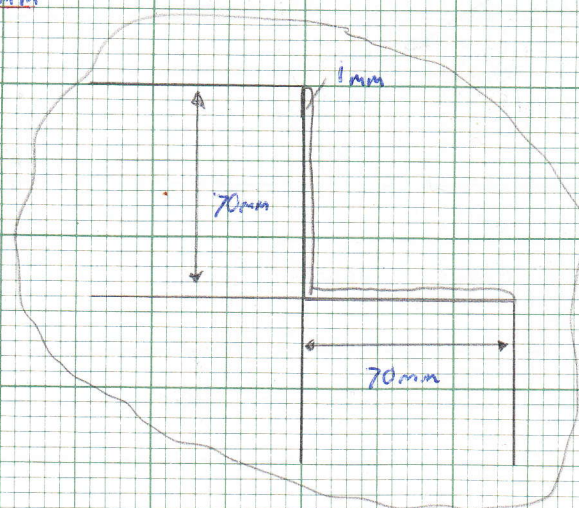


Diagram F7

Lesson 2

I then made indents in each of the four corners, where the marked lines crossed. Using the drill, I made four holes (one in each corner) where the marks were. The holes were made so that the sides, when bent, will fit together properly. Shown in Diagram F4.

After drilling the holes I used the corner ^{knocking} ~~cutting~~ tool in the flypress to remove the four corners. (The shaded areas shown in diagram F5).

Unfortunately the corner cutting tool was not big enough to cut the corners out in one go, so they had to be cut out ~~at~~ Bit by Bit instead (with assistance from gulmaz). Shown in diagram F6.

When cutting the corners it was made sure that the corners ^{were} cut on the safe side, leaving about 1mm which was filed down after. Shown in diagram F7.

After filing down the corners of the piece of metal, the swing beam bender was used to bend the sides into a box. Starting with ~~the~~ one of the 350mm sides, the piece of metal was placed into the swing beam bender (with the side pointing forwards) up ~~to~~ to the specific mark, then clamped in place.

Then taking hold of the swing beam, I pulled it up until the metal was at about 90° and then slowly let it down (as it was very heavy).

I undid the clamp, removing the piece of metal. Using the square I checked to see if the side was at a 90° angle. It wasn't. So I replaced the metal into the swing beam bender, clamping it tight, and bent the side a bit more - until it

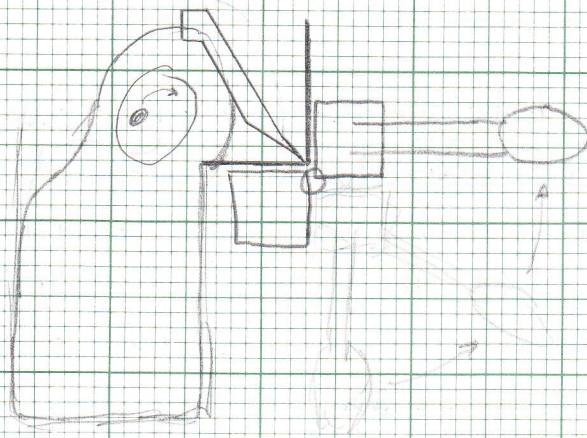


Diagram F8.

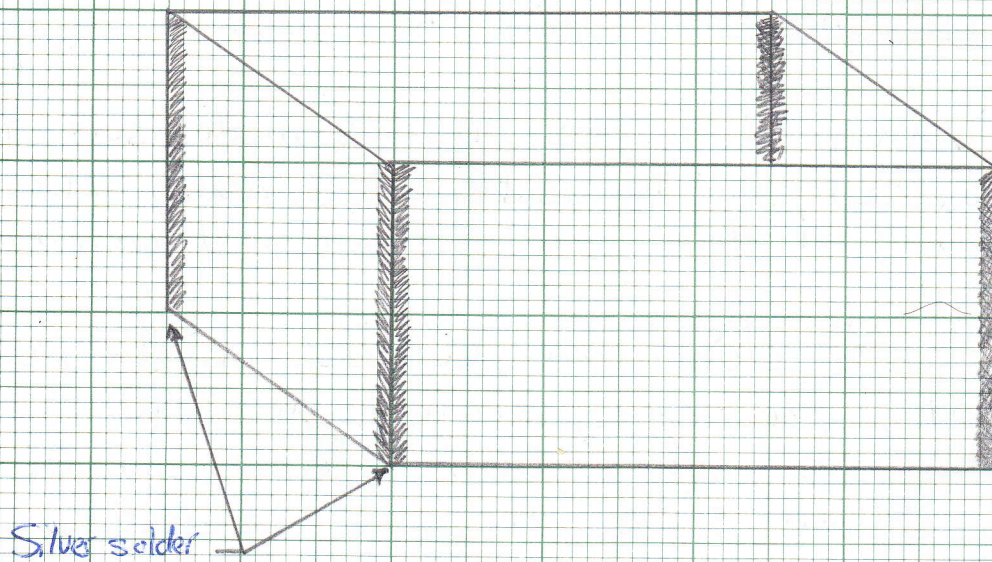


Diagram F9.

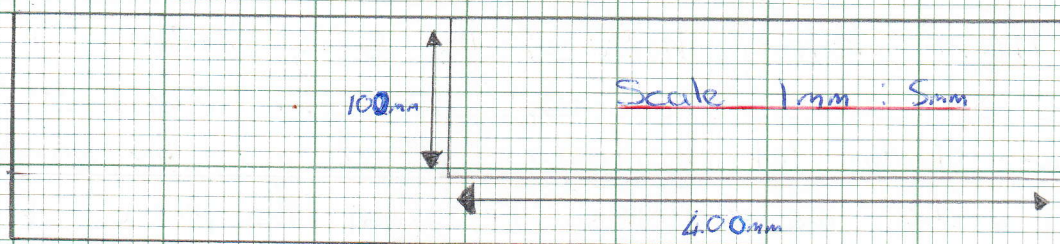


Diagram F10.

was at 90° . Shown in Diagram F8.

I then did the other 350 mm side, using the same machine. After bending the metal to about 45° , I found that the side which I had already bent touched the outer casing of the swing beam bender. The lecturer then said to use the pot and pan bender to finish the side off. I placed the side, which had been bent to 45° , into the ~~Box~~ and pan bender (this was done only after I had adjusted the amount of teeth in the machine, so that I had the required length). I then bent the side up to its full 90° .

Next I did the 2 70 mm sides, also using the ~~Box~~ and pan bender.

After bending all four sides I gave the box to the lecturer, who then used the ^{Oxy-Acetylene} gas welder to ~~silver~~ ^{fusion weld} solder the four sides together. Shown in diagram F9.

Then me and gulmaz used emery cloth to clean ^{the} solder off and also to clean the blue ink off the inside. After doing this the main part of the case was finished.

I then went on to do the lid. I started by taking a piece of metal, that was bigger than 400 mm by 100 mm as shown in diagram F10.

I then marked the main lid measurements on to the piece of metal and then using the Guillotine I chopped off the excess metal.

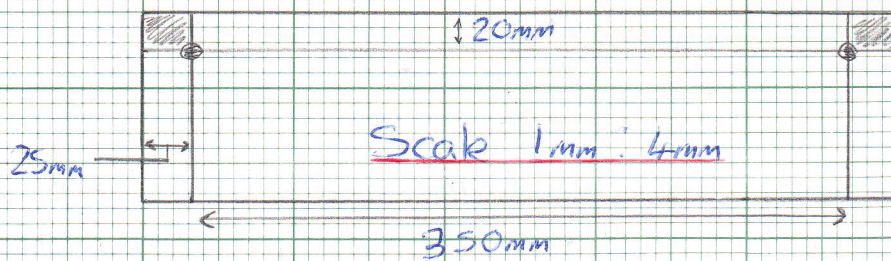


Diagram F11



Diagram F12

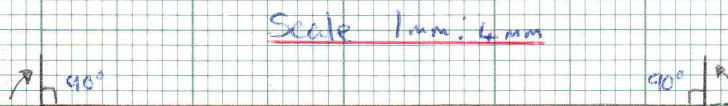


Diagram F13

After removing the excess metal, I marked the rest of the dimensions onto the lid. I then made indents in the two corners where the marked lines crossed. Using the ^{pillar} drill, I drilled holes in the 2 corners. Shown in diagram F11.

After drilling the holes I used the corner knocking tool in the flypress to remove the two corners (shaded in diagram).

Next I bent the long side by 90° into an upright position using the swing beam folder. I then checked the side, using the square, to see if it was at 90° . It was. (Shown in diagram F12).

After this I went on to bend the two small sides, also, by 90° into an upright position. I used the swing beam folder for both sides. After doing each side, I checked the angles using a square to see if they were at 90° . They weren't, so I bent each side a bit more and rechecked the angle until it was at 90° . (Shown in diagram F13).

Unfortunately one of the sides went over 90° , so I used the Box and pan folder to bend it back to the appropriate angle.

I then placed the lid onto the box to check to see if it fit properly. Unfortunately it was too small, so we had to recalculate the dimensions for the lid. So I started again, but this time making the main dimensions to be 105mm by 405mm.

The lesson then ended.

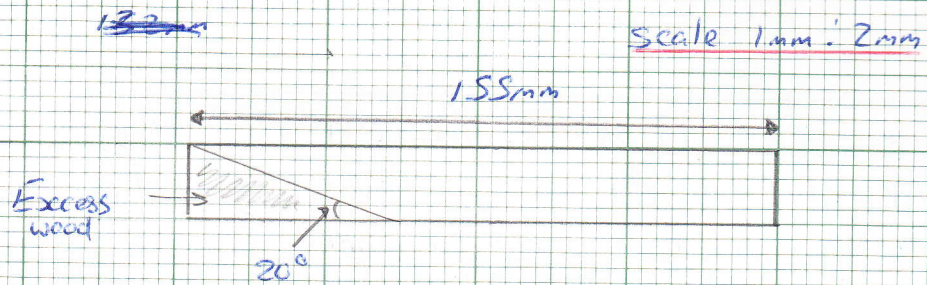


Diagram F14

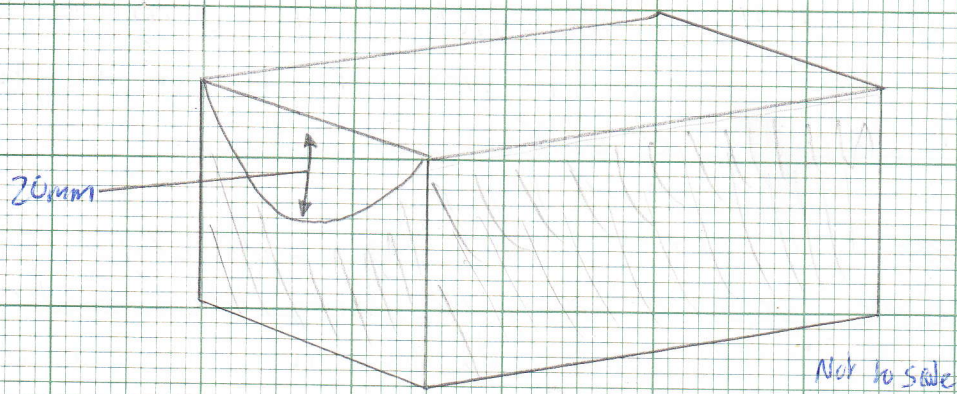


Diagram F15

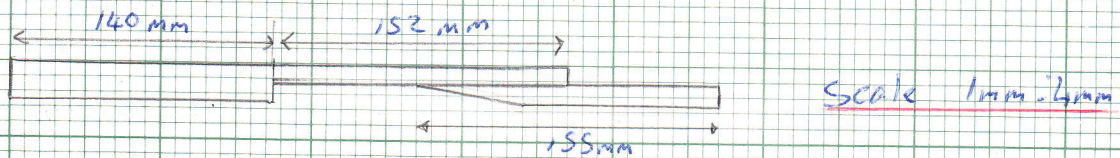


Diagram F16

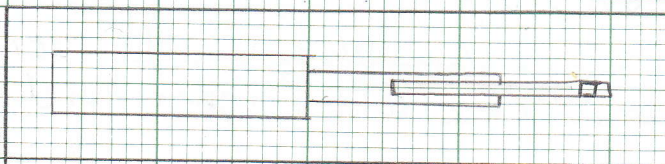


Diagram F17

Vacuum Forming

Taking the 155 mm Bar, using the belt sander, a slope of 20° was made at one end (shown in diagram F14).

Then the handle was made. Two pieces of wood were glue together and then, when glue had dried, the dimensions of the handle were drawn on to the wood (shown in diagram F15). On the sides using a protractor a 20mm radius semi circle was drawn.

Using the band saw the wood was cut carefully. The hard part was then to use the belt sander to remove the unwanted wood so it looked like a semi-circle. This was done carefully and it ended up as a good handle.

The two pieces of wood used for the base were glued together and then handle glued to the bar (shown in diagram F16).

When this had done, a piece of wood about 80×350 mm was cut. The edges of the wood were then rounded using the belt sander, and the pieces of wood were glued onto this wood. Shown in diagram F17.

Next the wood for the $\frac{1}{2}$ " drive was made. This was 15mm by 15mm. This was then stuck on the Torque wrench.

The lesson then ended.

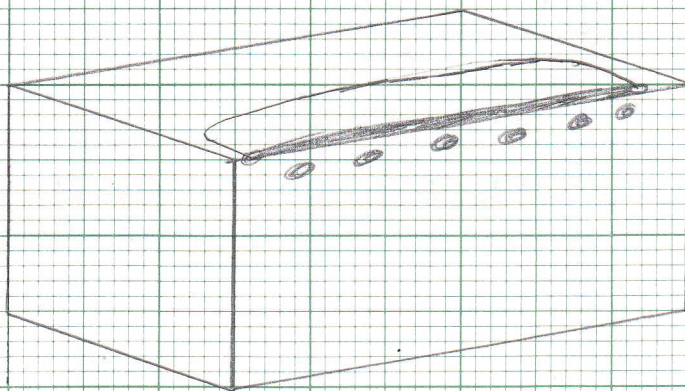


Diagram F18

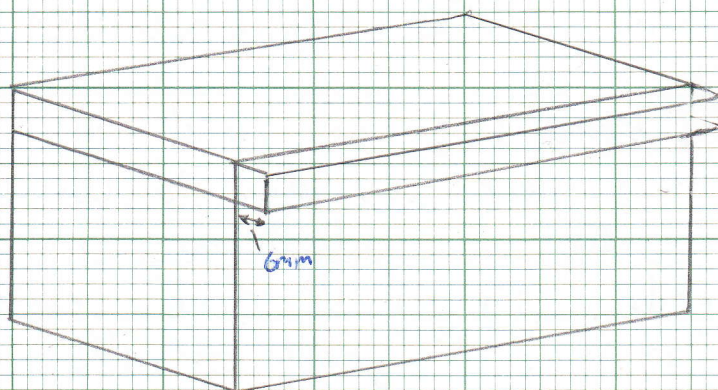


Diagram F19

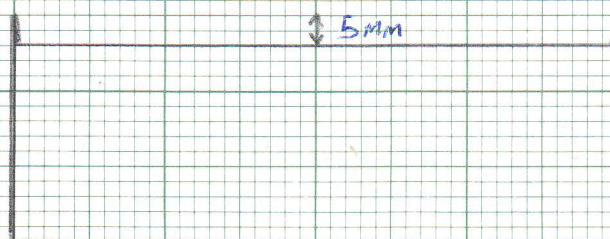


Diagram F20

Lesson 3

When I had finished bending the remade lid, it was placed on top of the box and it fit properly (apart from a slight catching in one corner).

We then took the lid to the lecturer to get the sides welded using the gas welder. Then using emery cloth the welding scale and marking ink was cleaned off.

Then we got a hinge and cut it to the right size so that it went the whole 350mm length of the box.

We then spot welded the hinge to the base of the box using a spot welder. Shown in diagram F18.

Then the lid was placed on top of the box and affixed in place by a single spot weld. Unfortunately the lid overhanged by about 6mm. (shown in diagram F19). The spot weld was removed and the corner knocking tool (flypress) was used to remove a 5mm strip along the back of the box. (shown in diagram F20).

The lid was then respot welded back onto the hinge and there was no overhang. Gulmaz then got a bit of a hinge and made a lock out of it, which was silver soldered onto the front of the box.

The lesson then ended.

Vacuum forming

When cutting the wood the bandsaw was set at an angle of 7° to cut a slope. The reason for this was that it would be easy for the mould to come out of its mould once formed.

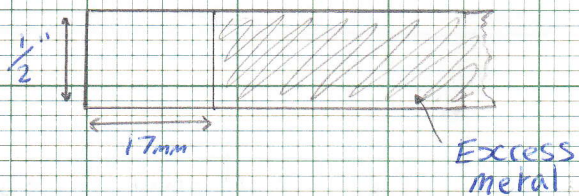
Once the wood had been stuck to the base the gaps in the wood were filled with car body filler so that the plastic mould, when formed, won't get stuck in the gaps.

The mould was then taken to the vacuum former. Firstly the μ mould was placed in the former and a sheet of plastic ^(2mm Polystyrene) placed on top. Then the plastic was heated till the plastic had gone soft, the mould was then brought up into the plastic and the vacuum pump was switched on. It was kept on until the plastic had formed the right shape.

The mould was then taken out off the plastic mould and the bandsaw was used to cut the unwanted plastic round the mould.

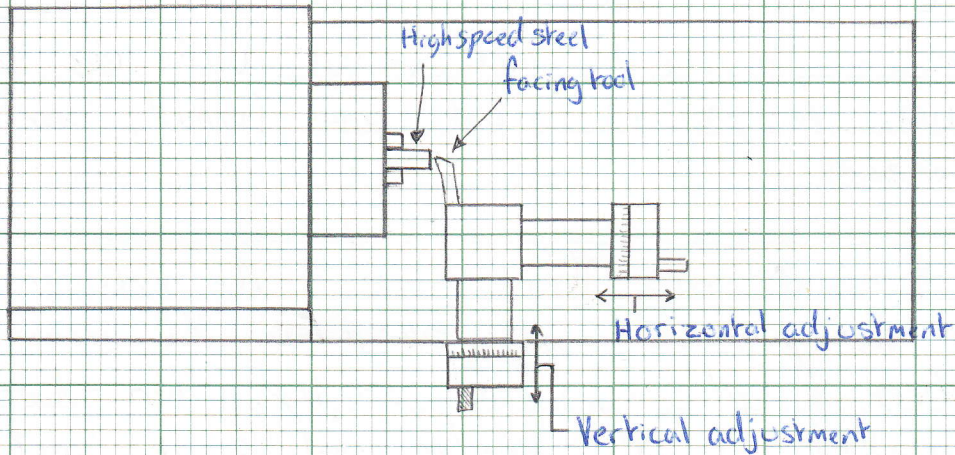
The lesson ended.

The Box and mould were not completely finished due to lack of time.



Scale 1mm to 1mm

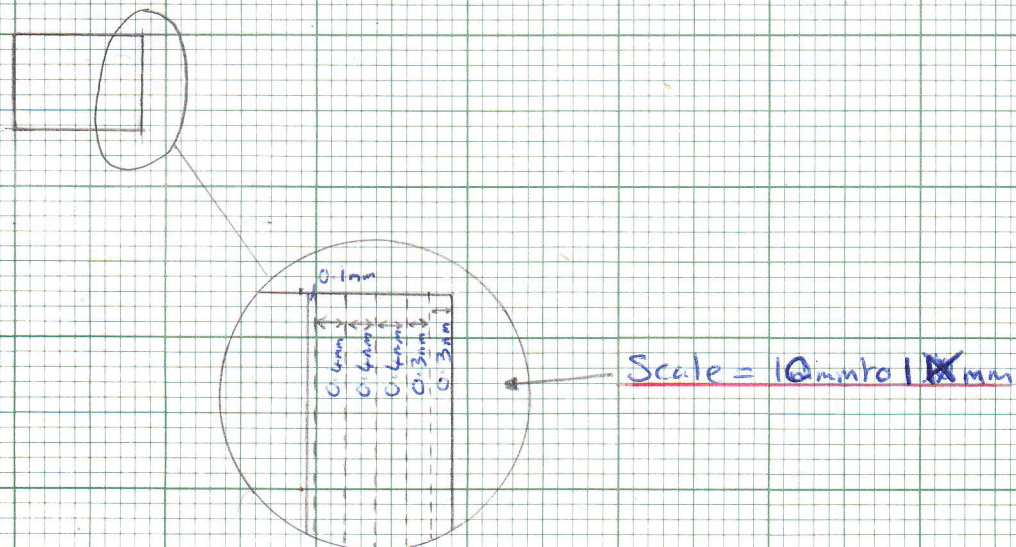
Diagram M1.



Not to scale

Diagram M2.

Scale = 1mm to 1mm



Scale = 10mm to 1mm

Diagram M3.

MACHINING

LESSON 1.

Introduction:

At the beginning of the lesson a leaflet was handed out, which stated the main dangers in the workshop. The lecturer then explained briefly what we would be doing during the three lessons of machining.

A second form was given out which was used for ordering each of the items of material we needed from the equipment store.

The lecturer then came round to each group separately and examined each group's designs to see if they were OK to manufacture. Then he discussed with each group how they were going to make their torque wrench. After speaking with the lecturer each group started manufacturing their torque wrenches.

Torque wrench:

Our group began by first making the $\frac{1}{2}$ " Drive, this was measured on to a $\frac{1}{2}$ " bar to a length of 17mm. (See diagram M1) The excess material was then removed using a hacksaw.

The centre lathe was then used for facing off the ends of the $\frac{1}{2}$ " Drive. The tools required for adjusting the lathe⁴¹ were collected from the equipment store. Once the lathe had been set up, the right hand turning & facing tool was aligned with the centre of the piece of metal (High speed steel). The facing tool was then positioned so that it just touched the face of the high speed steel, and the counter on the handle was set to zero. (Diagram M2)

The facing tool was then realigned so that it would remove 0.3mm of the face of the high speed steel. The lathe was then switched on and the 0.3mm of metal was removed, the facing tool was then readjusted so that

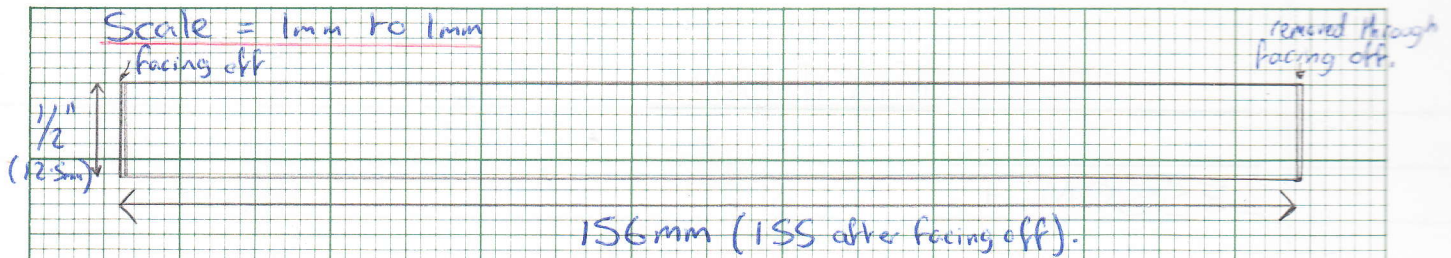
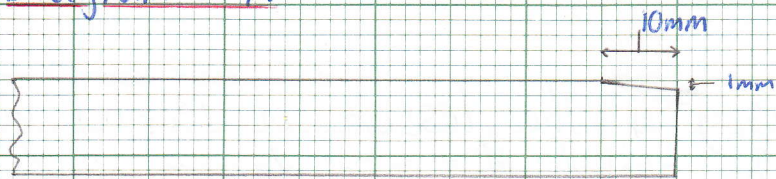
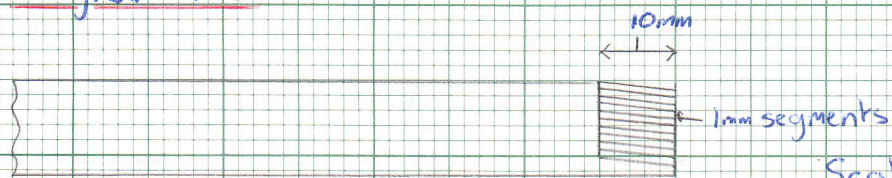


Diagram M4.



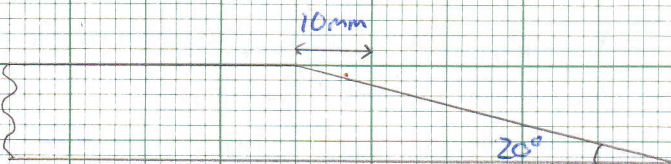
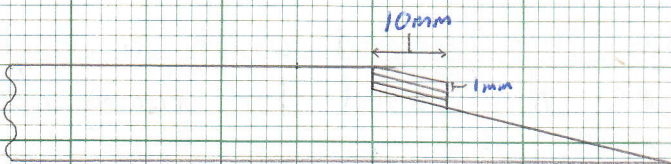
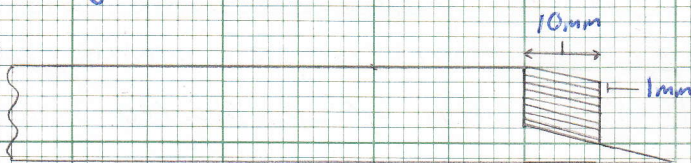
Scale 1mm to 1mm

Diagram M5.



Scale 1mm to 1mm

Diagram M6.



Scale 1mm to 1mm

Diagram M7.

another 0.3mm was removed (shown in diagram M3). The high speed steel was then removed from the lathe and its length was checked using a rule. Its length was just over 16.4mm. The metal was then replaced back into the lathe and the facing tool aligned so to remove 0.4mm of metal and then a further 0.4mm after that. The length of the high speed steel was then rechecked and was found to be 15.6mm.

The High speed steel was then placed the other way round in the lathe so that the other end could be faced off. A further 0.4mm was removed. The face was then checked for smoothness before another 0.1mm was removed. The length was then rechecked and found to be 15.1mm in length, - it was decided that no more metal would be removed.

The excess metal of the $\frac{1}{2}$ " bar was then used to make the next part of the torque wrench. The bar was measured to a length of 156mm and then the excess metal was removed using a hacksaw. Both ends of the bar were then faced off using the lathe (shown in diagram M4).

The vertical milling machine was then used, to cut an angle of 20° at one end of the bar. One of the lecturers set up the machine, adjusting the head to an angle of 20° in the mill. The mill was then adjusted so that it would remove 10mm's, in length, of metal and 1mm, in depth (Diagram M5). The mill was then turned on and the metal removed, coolant was used to stop the metal from overheating. After turning the mill off, the depth was readjusted so that another 1mm would be removed. This was done another 10-15 times until there was about 2mm's of metal left (Shown in Diagram M6).

The length was then readjusted so that a ~~10mm~~ further 10mm of the bars length could be milled. Again 1mm, in depth, of the metal was removed with each turn,

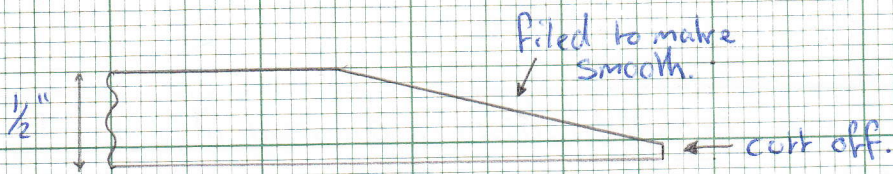


Diagram M8.

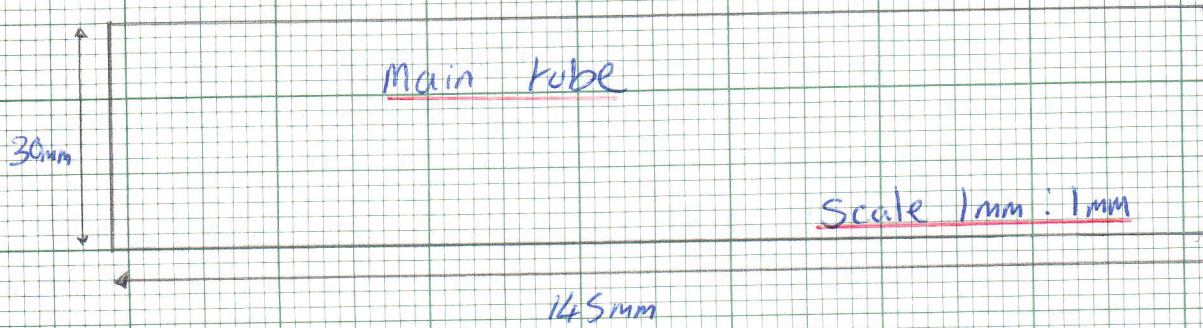


Diagram M9.

until the slope was level with the first one. This was done continually until the whole 20° angle slope had been cut (Shown in Diagram 7 on previous page).

The slope was then filed down, to make it smooth and the Hacksaw was used to remove the sharp edge at the end of the slope (shown in Diagram 8).

Next the main body, in which the circuit would be housed, was made. 145 mm was measured onto a piece of hollow steel tube and then the excess metal removed using a hacksaw (shown in Diagram 19). The horizontal milling machine was then used to smooth both ends. The Dimensions of the hollow part of the tube were 12 mm by 27 mm.

The lesson then Ended.

Not to scale

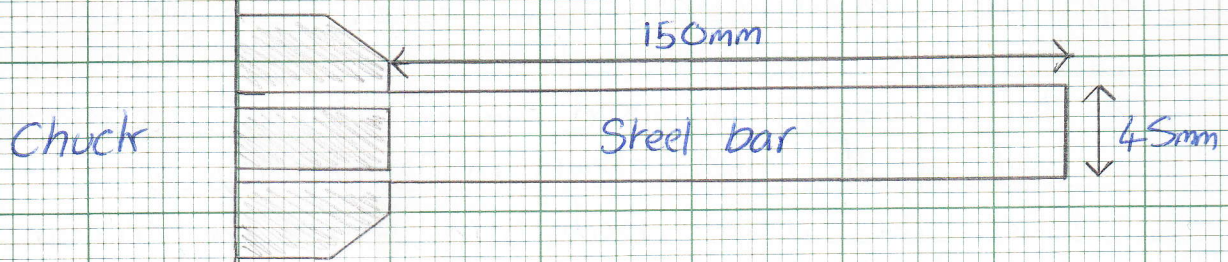


Diagram M 10.

Not to scale!

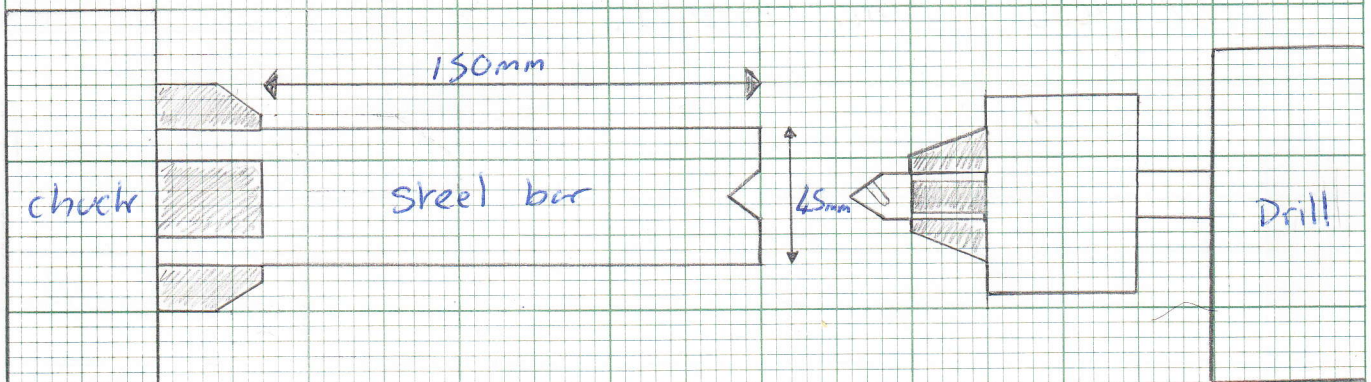


Diagram M 11.

Lesson 2.

Next the handle was made. For the handle a circular bar of 40mm ϕ was needed, unfortunately the closest they had in stock was 45mm ϕ . This meant the centre lathe had to be used to machine the bar down to a diameter of 40mm. The tools required for adjusting lathe L4 were collected from the equipment store.

(Diagram M10) The steel bar was then placed in the 3 Jaw chuck, leaving about 150mm showing. The bar was then locked in place using a chuck key. The right hand turning & facing tool was then attached to the lathe and fixed in place. It was then centred using the centre drill. The speed of the lathe was then calculated using the equation:

$$n = \frac{1000 \times S}{\pi \times d}$$

$$S = \text{cutting tool} \\ = 30 \text{ m/min}$$

$$\pi = 3.14$$

$$d = 45$$

$$= \frac{1000 \times 30}{3.14 \times 45}$$

$$= 212 \text{ (222 was calculated at the time).}$$

260 rev/min was the closest speed on the dial and so was chosen. The end of the steel bar was then faced off removing the rough bore.

The centre drill was then used to make a centre point in the end of the bar. A special drill bit was used which was placed in the drill. The speed of the lathe was then set to 800 rev/min and the lathe switched on. The drill was then wound in to the end of the steel bar to make a centre point. It was made sure that the drill went no more than 2/3 of the way up to the taper mark on the drill bit. The lathe was then disengaged (see diagram M11.)

Not to Scale

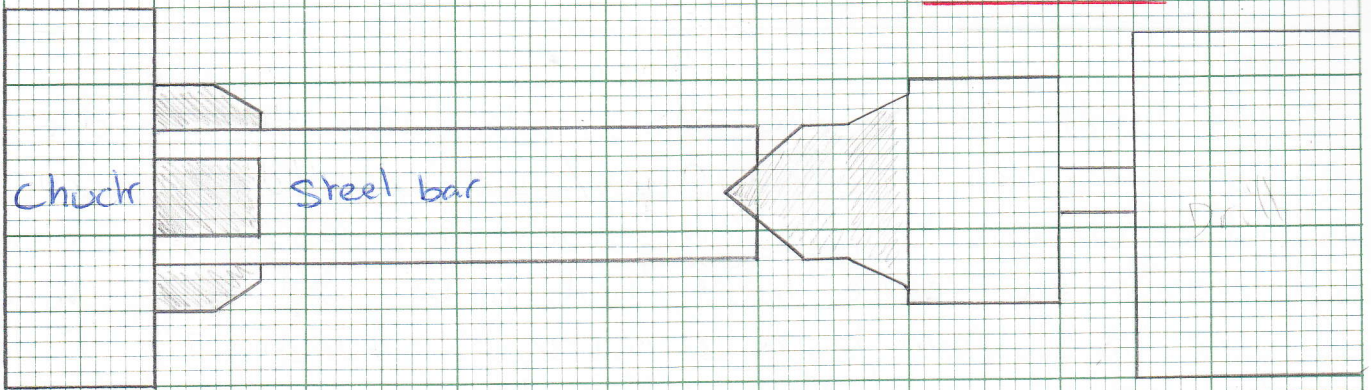


Diagram M12.

Not to Scale

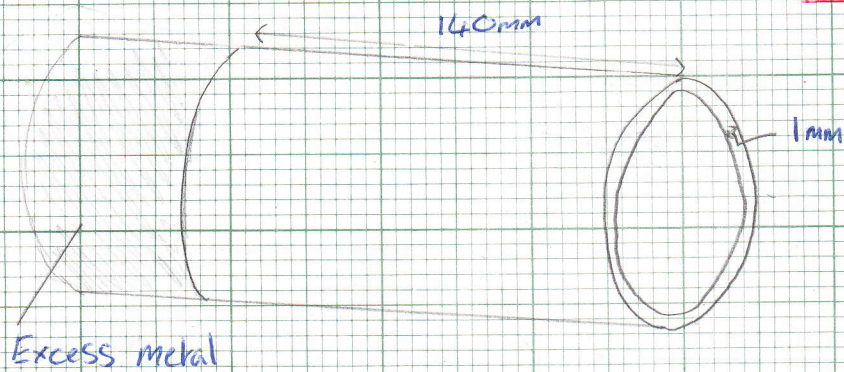


Diagram M13.

Scale 1mm to 1mm

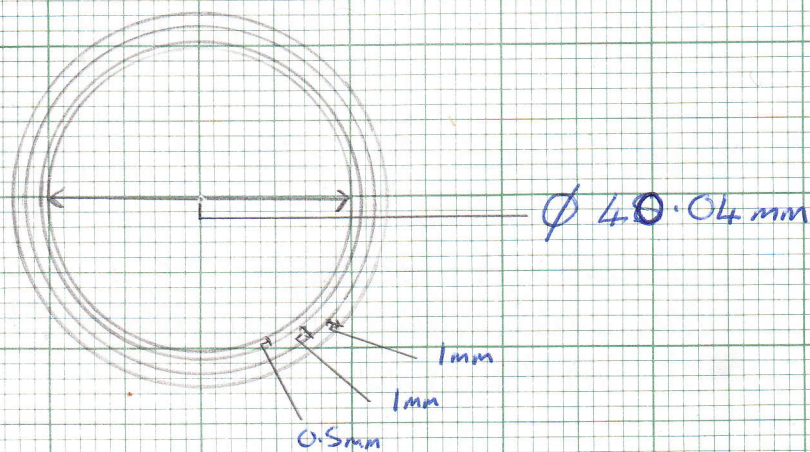


Diagram M14.

The main drill was then changed with the centre chuck and the drill was then moved back up to the bar, so that it fit tightly. This was done to prevent the bar from moving under cutting. (See diagram^{M12}).

The facing tool was then aligned so that it would remove about 1mm depth of metal. The carriage/saddle was then set to automatic, which cuts 0.3mm of metal off per revolution. Unfortunately due to errors in our design the handle's length had to be reduced by 10mm from 140mm - 130mm. (See Diagram M13).

The coolant was then turned on and positioned so that it would flow over the facing tool. This was done to prevent the facing tool and the steel bar from overheating.

The lathe was then turned on, with one member of the group standing over to check progress. Once the lathe had cut off 1mm depth of steel 140mm along the length (leaving 10mm spare) the lathe was switched off and the diameter of the steel handle was checked using a 25-50mm micrometer. 43.04mm was measured as the diameter.

The facing tool was then realigned so that it would remove another 1mm of steel. The lathe was then re-engaged and the steel handle cut until the facing tool had reached 140mm's along the bar's length. The lathe was then switched off and the diameter rechecked and found to be 41.04mm.

A further 0.5mm was removed and the diameter measured at 40.04mm. This was felt to be close enough to the diameter required, so no more was removed. (See diagram M14).

A tool called a knurling tool was then fetched from the equipment store and then attached to the lathe. The speed of the lathe was then adjusted to 80 rev/min. The knurling tool was then positioned so that it was fixed very tightly against the beginning

Not to Scale

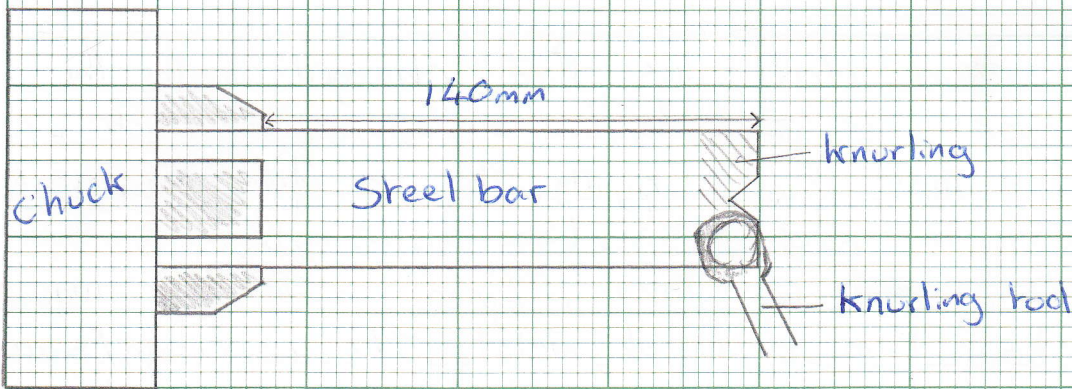
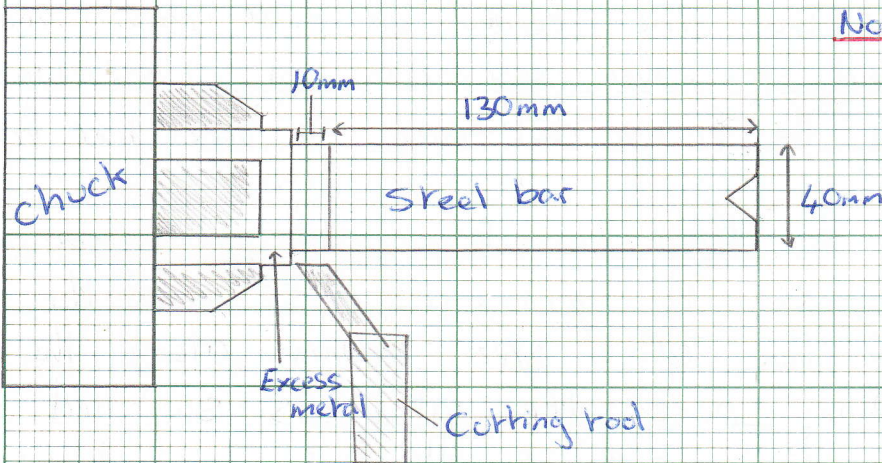


Diagram M15

Not to scale



This was done after
the below diagram

Diagram M16

Scale 1mm to 2mm

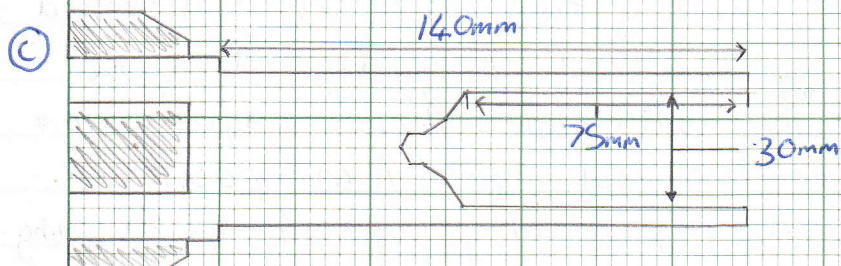
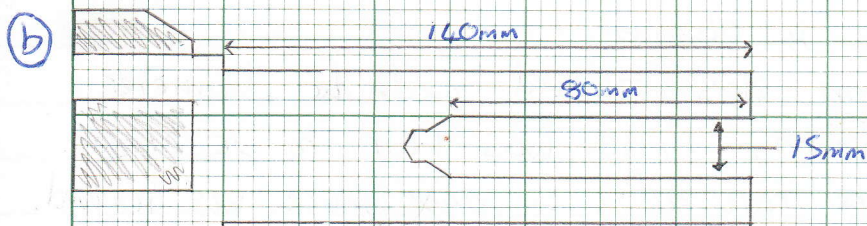
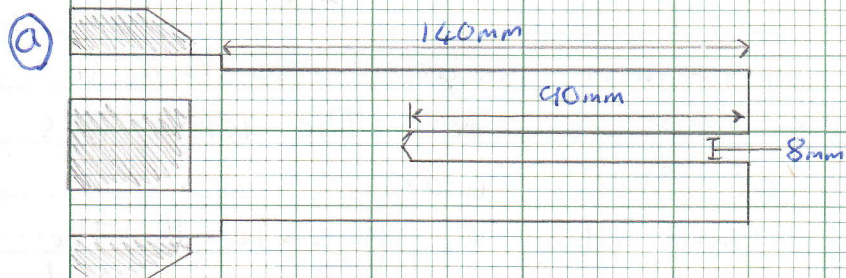


Diagram M17

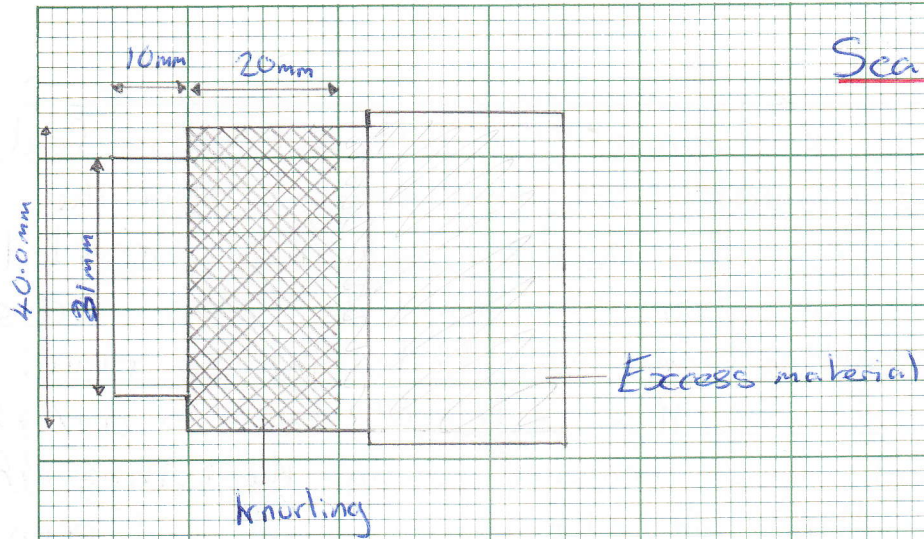
of the handle (See diagram M15). The automatic feed on the carriage/saddle was then engaged, and the lathe turned on. Once the handle had been knurled, the knurling tool was removed from the lathe and a tool called 'a cutting tool' was fitted in its place. The lathe's speed was then adjusted to 260 rev/min. The excess steel was removed using the cutting off tool (see diagram M16). When the excess steel had been removed the handle was measured and was found to be just over 130mm in length, which was expected.

Before the excess metal was cut off, a hole was drilled in the centre of the handle. This was done with 3 Drill bits: 8mm, 15mm and 30mm. The 8mm drill bit was used first, with this drill bit the lathe was set to 625 rev/min. A hole, 90mm in depth, was drilled in the end of the handle (see diagram M17a). Next the 15mm drill bit was used, the lathe was set to 350 rev/min. A hole of 80mm was then drilled with this drill bit (see diagram M17b). Finally the 30mm drill bit was used with the lathe set to 190 rev/min a hole of about 75mm was drilled (see diagram M17c). A battery was then found and placed in the hole that had been drilled, and it fit perfectly.

Once this had been done the excess steel of the bar was removed, as stated above.

A piece of plastic bar, about 80mm in length, was collected from the equipment store. This was to be used for making a plastic end cap for the handle. The plastic bar had a radius of 45 ϕ and so was machined down to a radius of 40 ϕ using Lathe L4. After doing this the plastic cap was knurled using the knurling tool.

The first 10mm of the cap was then machined down by a further 7mm until at a diameter of 33mm. The cap was then taken out of the lathe and tested



Scale 1 mm to 1 mm

Diagram M18.

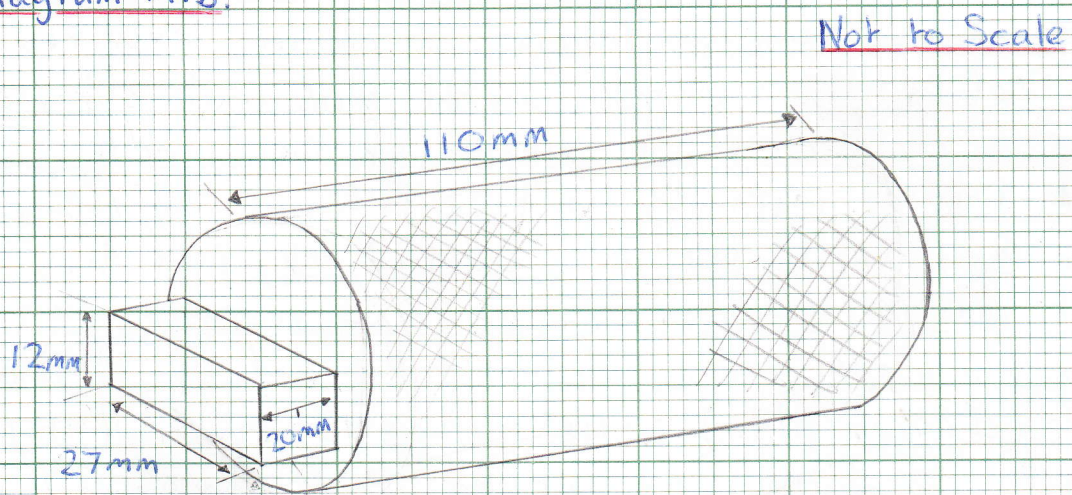


Diagram M19.

Scale 1mm to 1mm

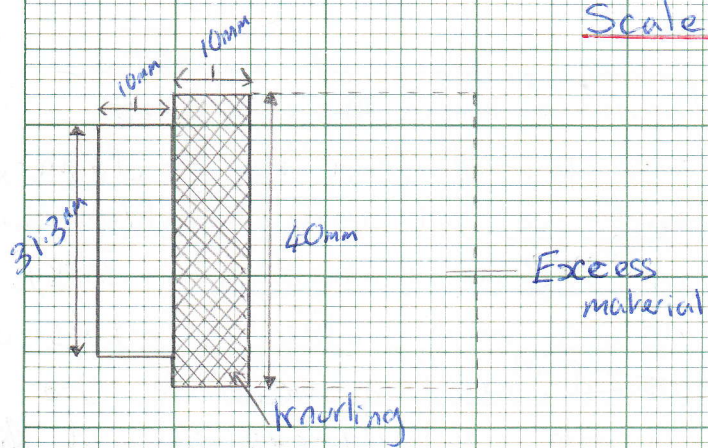


Diagram M20.

Scale 1mm to 2mm

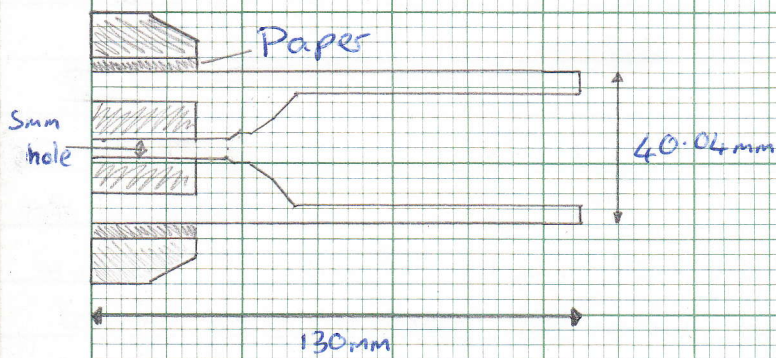


Diagram M21.

Scale 1mm to 1mm

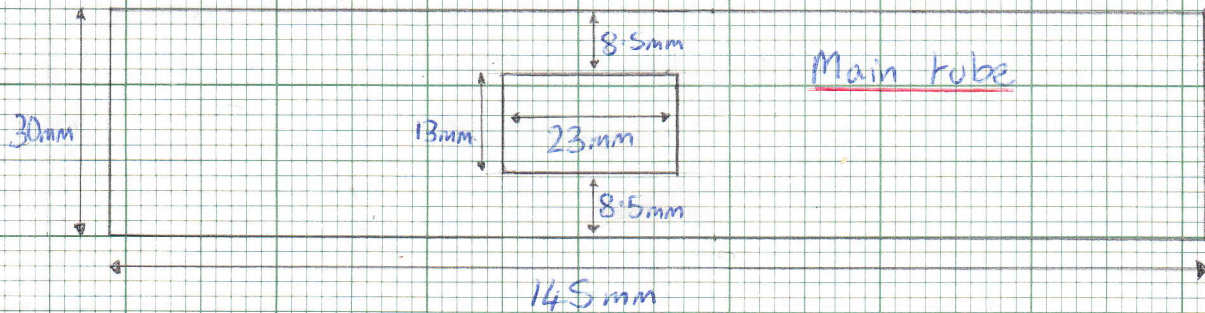


Diagram M22.

Not to scale

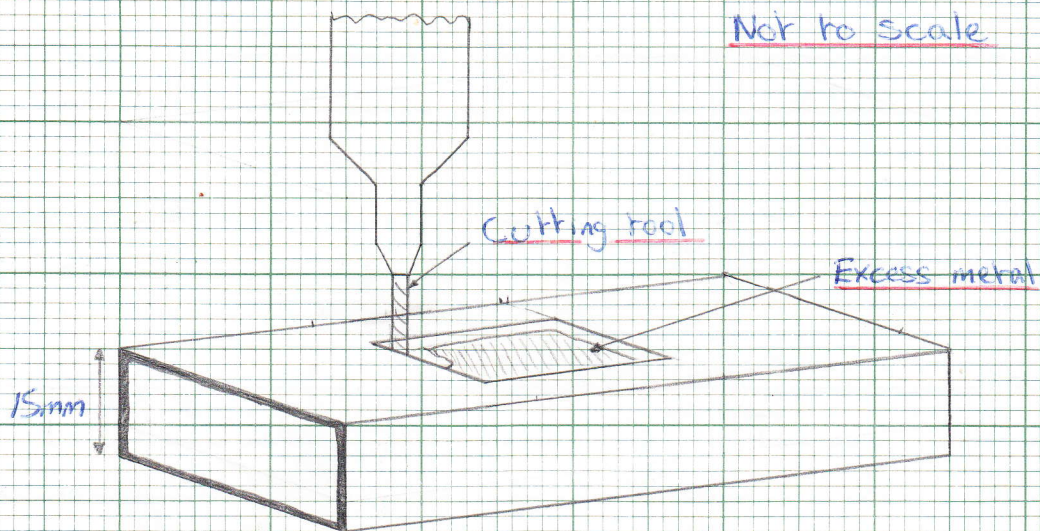


Diagram M23.

Lesson 3

Used the cutting tool to cut off excess material from cap (see diagram M20), the cap was then complete.

The end of the handle (which had been machined on the ~~horizontal~~^{end} milling machine) was then filed down so that it fit tightly into the end of the main tube.

After removing the handle from the tube, it was replaced in the lathe and a 5mm drill bit used to drill a hole through the centre of the handle (See Diagram M21). This was done to enable wires from the battery clip to be passed to the PCB in the main tube. Paper was used to prevent the 3 jaw chuck from damaging the knurling on the handle.

Next a hole was cut in the top of the main tube. This was made so that the PCB could be seen by the user. The hole was cut using the horizontal milling machine. The dimensions for the hole were 23mm by 13mm, these dimensions were marked on the tube using a scriber (shown in Diagram M22).

The tube was fitted to the horizontal milling machine and fixed tightly in place. The cutting tool, which was fitted to the milling machine, was aligned with one of the corners of the marked area. The milling machine was then turned on and a hole drilled. The carriage/saddle (which the tube was attached to) was slowly adjusted length ways, so that the cutting tool cut along the inside of the marked line, until reaching the next corner. The carriage/saddle was then adjusted width ways so that the cutting tool continued to cut along the inside of the line. Once the next corner had been reached the carriage/saddle was adjusted length ways, and then finally width ways until the metal was removed (shown in Diagram M23). Coolant was used to keep the metal cool under cutting. The tube was removed from the

Scale 1mm to 1mm

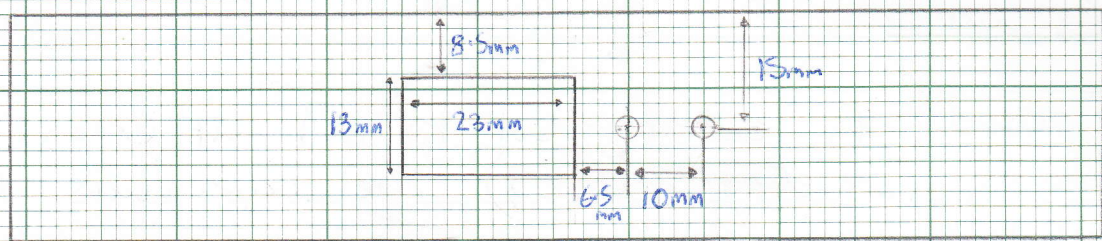
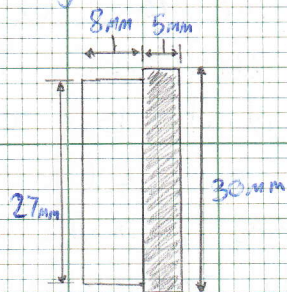


Diagram M24.



Scale 1mm to 1mm

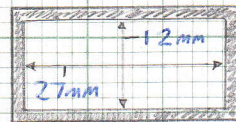


Diagram M25.

horizontal milling machine.

A marking out kit was used to mark two points for drilling. A 3mm drill bit was collected from the equipment store and then attached to the drill. The tube was then positioned under the drill. With the drill being switched on, a hole was drilled through one of the two points. The tube was then repositioned so that the second point was under the drill bit. This was then drilled and the drill turned off. The dimensions for the 2 holes are shown in diagram M24. The PCB was then placed inside the tube to see if it fit properly, it did.

A plastic cap was then made using the End milling machine (Dimensions for this, shown in Diagram M25). The cap's purpose was to fit in the end of the tube, so as to seal off the circuit board making it water proof. It also made the PCB easy to access. At first the cap didn't fit into the end of the tube and so a file was used, to file down its sides. The cap was then re-tried but still did not fit and so was filed down again. This was repeated ~~over~~ until the cap fit properly.

We were informed by the lecturer that the $\frac{1}{2}$ " drive that had been made was not long enough for there to be enough space for welding. This meant a new one had to be made, with the length being increased from 17mm to 20mm. A piece of $\frac{1}{2}$ " steel bar was measured up using the marking out kit and then the excess metal removed using a hacksaw. Both ends of the $\frac{1}{2}$ " Drive were faced off using Lathe L1.

The lesson then ended.

Scale 1mm to 1mm

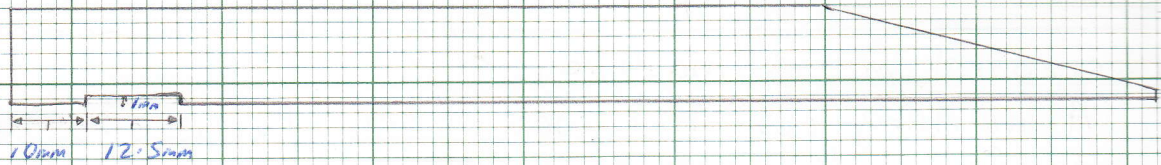


Diagram M26.

Scale 1mm to 1mm

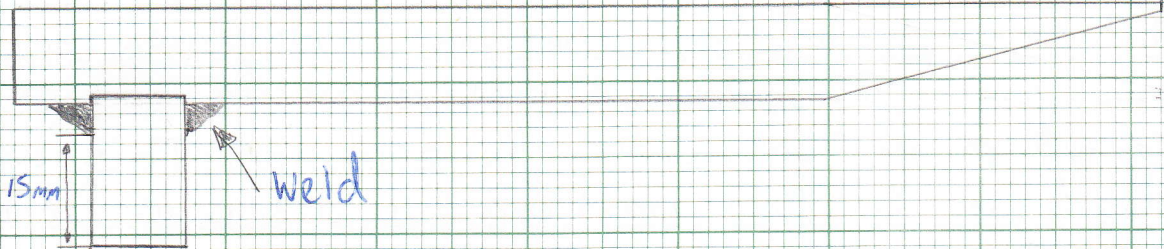


Diagram M27.

Scale 1mm to 1mm

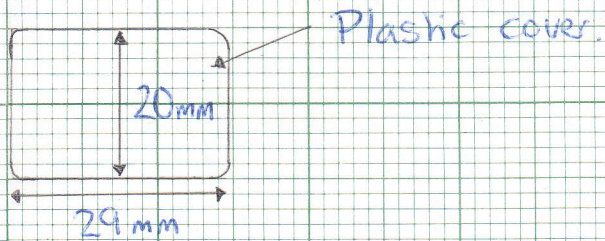


Diagram M28.

Finishing OFF and Testing.

The last two lessons were dedicated to finishing off any parts of the torque wrench that needed completing and testing the torque wrench.

Lesson 1

The handle for the case, which had already been bent into shape, was welded to the lid using a spot welder.

Due to changes to the dimensions of the torque wrench, it would no longer fit in the vacuum formed insert. The wooden template was altered slightly and then a new vacuum formed mould made, using the vacuum former.

We then made a 1mm deep groove in the bar using the vertical milling machine. One of the lecturer's set up the machine, adjusting the head to an angle of 0° . The groove measured 12.5mm in length and was 10mm in from the end of the bar (shown in diagram M26). The reason for the groove was to prevent the $\frac{1}{2}$ " Drive from being twisted off when heavy loads are applied.

The lecturer then welded the $\frac{1}{2}$ " Drive into the 1mm^{deep} groove on the bar (Diagram M27). While the $\frac{1}{2}$ " Drive was being welded a plastic cover was made for ~~the~~ covering the hole in the main tube. The dimensions (shown in Diagram M28) were marked on PVC plastic and then it was cut out using the bandsaw. Once cut out the plastic was filed round the edges to make them smooth.

The vacuum formed mould was cut to the right size ~~on~~ with the bandsaw and then sanded down using the belt sander, until it fit^{rightly} in the case.

Not to scale

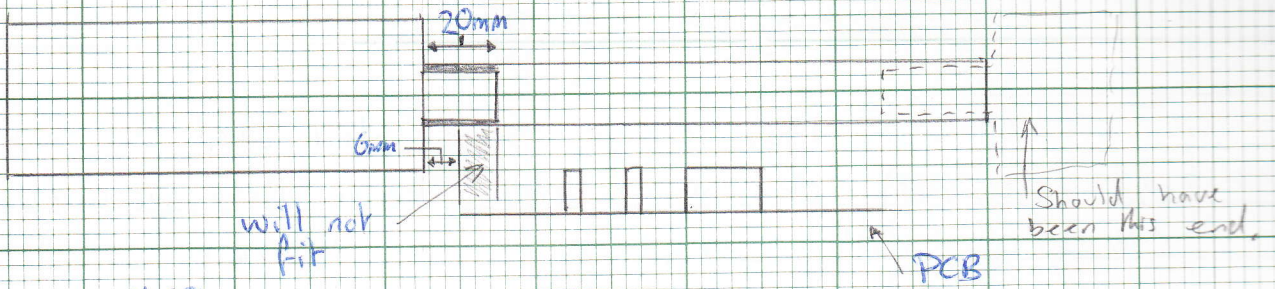


Diagram M29

Final Lesson

Main tube was welded to the bar and $\frac{1}{2}$ " Drive. Unfortunately the tube was welded the wrong way round. This meant the pcb would no longer fit in the main tube, if the handle was attached (Shown in Diagram M29).

This meant that the end of the handle had to be cut down from 20mm to 6mm, using the end milling machine. Once this had been done the end milling machine was turned off and the ~~box~~ Handle removed and attached to the main tube. The PCB was then placed inside to check that it fit, which it did. The handle and tube were then welded together.

Longer wires were then connected to the battery clip and the pcb placed inside the torque wrench. The torque wrench was now complete enough for it to be tested.

The torque wrench was connected up the test rig and a weight of 54 kgs was on the torque wrench's handle. The PCB display read 57N, so this was recorded on the test sheet. Weights were then taken off, so that the weight on the handle was now 18 kgs. The PCB display read 18N, so this was recorded on the test sheet. More weights were then taken off, so the ~~the~~ mass on the handle was further reduced to a mass of 8 kgs. The display was then rechecked and found to be 9Ns.

The plastic cover for the hole in the main tube was then stuck on using superglue and the 2mm polystyrene vacuum formed mould was fixed into ~~the~~ the case, with a small hole being made in the mould. This was due to the ^{main tube} ~~mould~~ being welded the wrong way round.

The lesson then ended.

