National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Technology Level 3

This exemplar supports assessment against:

Achievement Standard AS91622

Implement complex procedures to make a specified product using a Computer Numerical Controlled (CNC) machine

An annotated exemplar is a sample of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at boundaries of each grade.

New Zealand Qualifications Authority

To support internal assessment

Grade: High Not Achieved
For Achieved, the student needs to implement complex procedures to make a specified product using a Computer Numerical Controlled (CNC) machine. This involves: • integrating the limits of a CNC machine into a graphic representation of the desired product in a computer design setting that demonstrates an understanding of CNC programming language • setting up and calibrating a CNC machine to software and manufacturer requirements • operating a CNC machine to make a product in compliance with relevant health and safety regulations • evaluating a CNC machine-made product against its graphic representation. There are partial indications of understanding in each area, placing the work at high Not Achieved, but the depth, technical proficiency, and completeness required for Achievement are not present. The workflow evidence demonstrates that an image was imported, vectors were traced, the board was sized, and a toolpath was selected in Aspire. However, the evidence does not demonstrate understanding of CNC limitations such as toolpath strategy, cut-depth decisions, the constraints created by tool diameter and line width, expected material behaviour, or machine bed limitations. These omissions mean that the requirement to integrate machine and material limits into the graphic representation is not met. CNC setup is present, and the description of zeroing X, Y, and Z using the paper method and positioning the bit shows the procedure occurred, but it remains descriptive only. There is no explanation of why the chosen zeroing method was appropriate, how accuracy was ensured, or how feed or spindle settings were confirmed, elements that are required to demonstrate correct and justified setup. Safety is referenced only implicitly, with no explicit health and safety evidence provided. Achievement requires clear demonstration that the CNC machine was operated in compliance with health and safety regulations. The absence of identifiable hazard controls constitutes a significant gap in the evidence. The evaluation states that the final product “looks exactly like the graphic design,” but no visual or measured evidence is provided to support this claim. There are no comparisons between the cut outcome and the Aspire (graphic representation) model, no measurements of depth or positional accuracy, and no commentary on quality indicators such as edge finish or tool marks. The evaluation is reflective but does not evaluate accuracy against the graphic representation, which is necessary for Achievement. To lift the work to Achieved, the evidence needs to explicitly show compliance with health and safety expectations during CNC operation. A clearer explanation of how the final cut aligns with the Aspire model (photos, measurements, or specific commentary) would also be required. Additionally, a brief justification of CNC choices such as toolpath selection, tool bit choice, zeroing method, and feed/spindle settings would help demonstrate the level of understanding needed to meet the standard.

High Not Achieved

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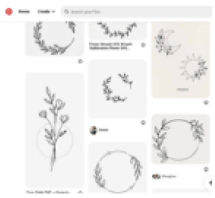
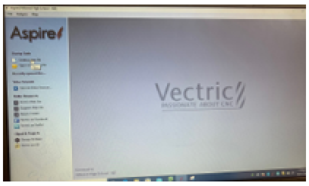
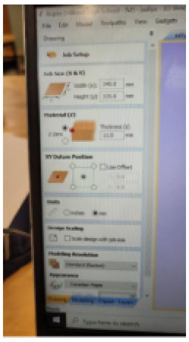
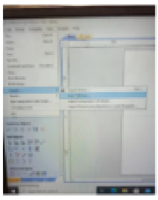
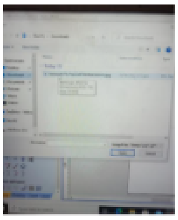
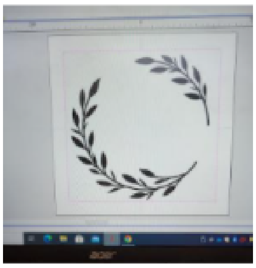
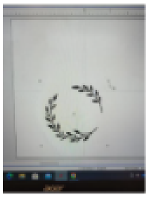
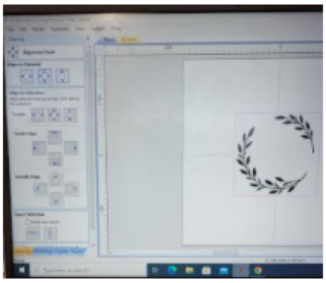
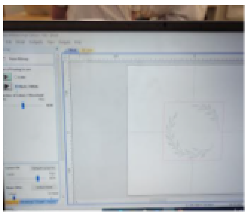
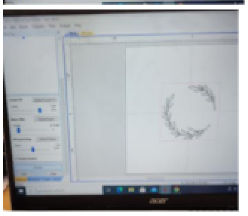
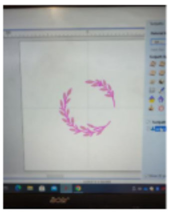
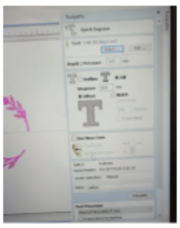
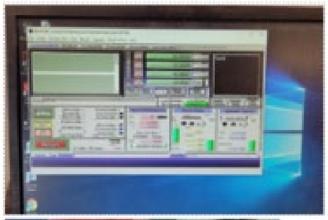
Vector Modelling software	Aspire
Machining software	Mach3 Loader
Tools used	Drill bit V-Bit (60-degree 6 mm)
Toolpaths used	Pocket pathway

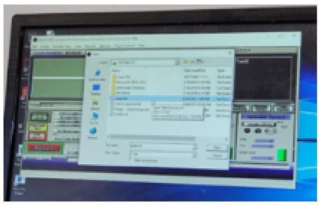
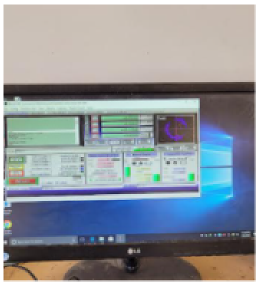
Image	Step description
	Find an image for what I am looking to have engraved on my serving board.
	Create 'new file' on Aspire (Vectric Modelling software)
	Set the size of the material being used. This includes the width, height and thickness. Also click the circle in the middle for XY Datum Position before continuing to the next step.

	Import bitmap by going to file > Import > Import Bitmap
	Select the downloaded image you have saved previously and click 'Open'
	The selected image with now appear in the middle
	Change the size of the image

	Centre the image by choosing the centre option for 'Align to material'
 	Choose the Black/white option for 'type of tracing to use' and then click proceed. The black outline of the image will then appear.

	Click on the pink outline and then click on 'toolpaths.
	Select tool - V-Bit (60-degree 6 mm) and apply. Calculate before clicking 'Mach ⅔ Arcs (mm)(*.txt). Save toolpath onto a USB stick
	Position the base of my serving tray

 	Set up the computer and press the 'reset' button. Use the keyboard to move the bit to the middle of the serving tray and place a piece of paper between the bit and the board. Move the bit vertically down so that just a bit of the tip touches the board. Click 'Zero X', 'Zero Y' and 'Zero Z'
	Click on 'File' and open 'Load G-Code'

	Click open after selecting the correct document
	Click 'go to zero' before clicking 'cycle start'
	When the machine is finished with engraving my serving tray, it will look like the image on the left

Evaluation

Write a brief evaluation of the process you undertook to achieve your outcome, be sure to include how your final product represents the graphic model (in Aspire) you have created

During the process I took to achieve my outcome, I had no difficulties apart from finding a suitable design to cnc onto my serving tray. The hardest part of this process was finding a detailed design that would not chip when being engraved. I wanted a circular floral/ greenery themed design in the middle of my serving tray but had to change my design a few times to find one that was suitable. I had originally planned to have a mandala design engraved on my board but after a test run on spare wood laying around, it was clear that the design was not going to give me a great outcome due to its complexity. There are so many lines on this design, and they were so close together that the pieces in between began chipping away. After coming across this limitation, I decided to find a less complex design that can be filled in so that the small details won't chip away like it did during my practice run using the mandala design. I decided to fill in my final design instead of having an outline to avoid chipping as there are some small details on it. By the time that I found a design that was suitable, I had gotten the steps to create the toolpaths fully memorised in my head which made it quick and easy for me to create the toolpaths for my final design. My final product represents the graphic model (in Aspire) that I created as the final engraved

Grade: Low Achieved
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Low Achieved

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Limitations

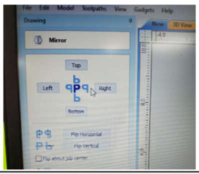
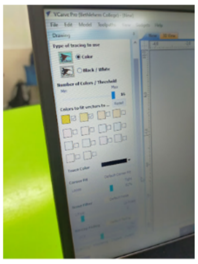
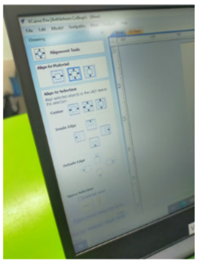
List the limitations of the CNC Router and explain how these will affect your product

-Tool bits. The school only has limited tool bits to put into the machine so it limits what I can do on projects

-Time. Since there are only two CNC machines and a whole class doing this topic I will have a limited amount of time to do it. Since I finished the coding before most of the people in my class I got to be one of the first people to used the router so I did not have to wait long.

1 -Size. Since the CNC router has a limited area to work on the size of my project will be limited to the bed size of the machine as well as the height being limited as well.

-Material. Due to covid the types of materials that we can work on is limited. Due to this project needing two different coloured wood and us only having access to two different woods, we only got to choose which one was going to be the background and which one was going to be the picture.

VCarve function	Explain why you used this function	Screen shot
Mirror tool	*Used the mirror function to flip the design vertically, so that the image could be viewed in the correct orientation through the clear acrylic plastic*	
Tracing tool	Used the tracing tool to trace the outline of the picture. From this I can code if I want the inside or outside of this outline to be cut out.	
Alignment tool	I used the alignment tool to put the image in the centre of the work so when I use the router to cut it out it will be in the middle of the wood.	

2

Set correct zero position (X, Y, Z- depth)	I made the starting point, for where the tool path should start, in the middle of the wood on which I am working on. So when I am setting up where I should put my wood I have to move the tool bit so it is touching the middle of my piece of wood and the I'll zero the X, Y and Z. I have to do this because if not the image getting cut out would be wrong. If X is wrong the image would be moved up or down. If Y is wrong the image would be moved sideways. If Z is wrong the image would be cut too deep or shelow	
Set required feed & spindle rates	We put the feed and spindles rates down to 40-60%. We do this because if it too fast or too slow it could cause damage and reck the wood.	

Dust 3	Vaccum	
Sound/hearing lost	Earmuffs	

Evaluation

Critical thinking:

What are you thoughts on the finished products; 4

- Accuracy in relation to the Vcarve software preview,
- The quality of your finish (engraving, cut outs etc)
- Any problems you encountered
- Future refinements that could be made

My overall thoughts on my project is that it is pretty accurate and well made. The accuracy is good considering that all the lines are curved while the router works better for straight lines. The quality of my finish is good as well as there are no gaps between the two pieces of wood. The only problems I encountered were not putting the clamps out far enough (the tool bit hit them) and someone stealing one of my shoes so one or two of the days I could do nothing. For the future I think the best refinement would be to make the picture not as detailed and have as many curved lines as it took a while to cut out and it could have ended badly if I did not clamp it down or something. Overall I am very happy with my project.

Grade: High Achieved
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High Achieved

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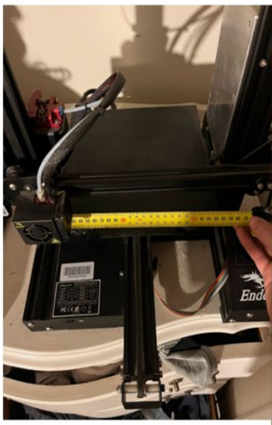
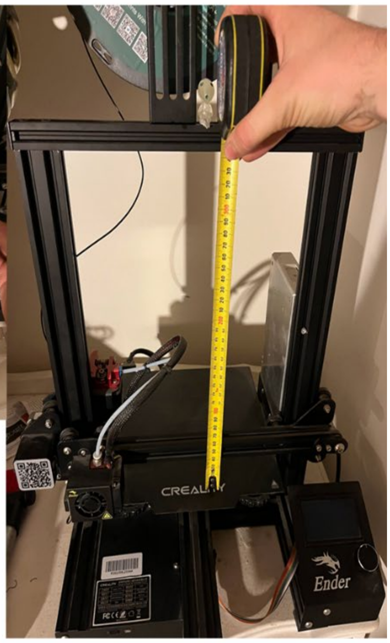
1

Bed size capabilities and of printer

In this sled i took into account the printing scale of what i'm making. eg Will it fit into the printing bed of the Ender 3 pro? How much space will i have what is the max height what is the width and length. We can see in the photos that there is more than enough space as my product is only (91mm long /90mm wide /32mm tall) and the bed has 235mm-235mm bed size with a max height of 250mm.





Correct setup of temp and ect

With 3d printing there are many verables that can affect qallty and if the print will fail or suckseed. These verables are. Temp speed feed, rate plastic qallity ,age and moisture, moter funchon dust ,file qallity ,basics settings ,nozzle ajustmint.

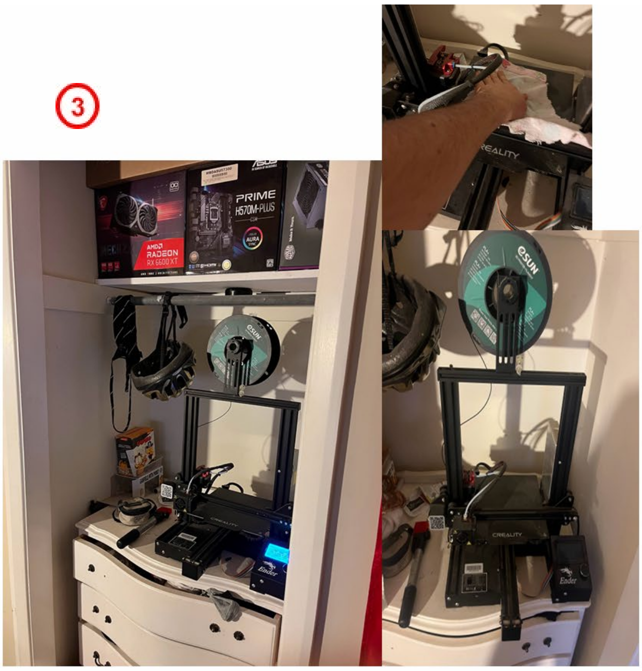
For temp i used 200c for the nozzle temp as i is the factory recommend teprece of the printer and for the bed i used 60c for the same reason. For the plastic it can lose strength with moisture so i have kept it in a dry environment to prosvers this. I have tested the moter and feedrate shown in the image so see if they still work as intend. File qallity was fixed about 5 months ago so it is all updated in the slicer and good to go. Before printing i fine tuned the nozzle so it sould be perfect.

2

Health and saftey

3

When 3d printing there are meany health and safty riskes such as burns form nossle and bed. Fire risk and posions gas. To keep thses minamised have been working on health and safty. For the gas i use Pla plastic a safe none toxtic plasic that has a low melting point and dosent release gas into the area. For the fire risk i keep the printer clean and make to not to leave it unattended at all times. I do this via keeping it in my room wile i am at my work desk as well as cleaning the printer with brush befor every use. For burns i keep the printer in a corner of the room to minamise it being bumped into and causing damage. The rest of the time the printer is relatively noisey and makes it self well known.



Accessing and viewing product after print compulsion.

4

Once leaving the 3D printer work for the day while watching it. the print was complete I measured it compared to the original diagram online and it came out as a 1 to 1 replica, (91mm long /90mm wide /32mm tall) which means that there was no inconsistency with sizing. checking the quality of the print showed no cracks Or warping in the printing which shows the sign of a successful and strong print. testing it to see if the metal pipe would fit within the print it came out successfully and increased the rigidity of the structure. The only minor fault was where the raft aheeing to the print leaving a bit of scoring but this is inevitable with using a raft to print on.

xxxxx good job getting the CNC standard finished at home. I think there are some areas that you could have gone into a lot more Depth with which would help secure your grade, things like: Initializing the printer, how did the clean the printer before use, What are some of the tips and tricks you've learnt from the 5 years experience, nozzle offset and layers.

You have touched on all the necessary points for an achieved. 5

Grade: Low Merit
For Merit, the student needs to skillfully implement complex procedures to make a specified product using a Computer Numerical Controlled (CNC) machine. This involves showing independence and accuracy in undertaking the procedures. The evidence demonstrates that complex procedures were implemented with independence and accuracy, as required for Merit. The digital workflow shows understanding of machine envelope limits and appropriate file handling (1). This is seen in the duplication of the workspace, scaling of the model to fit and exporting of individual components as STL files. These actions indicate accurate management of file types and preparation suitable for a CNC process such as 3D printing. Further independence is shown through the upload of files into UP Studio (2), where parts were rotated and positioned to reduce support and printing time, providing evidence of thoughtful optimisation decisions. Technical accuracy is demonstrated through explanations of key slicer settings and their functional impacts. The evidence shows understanding of parameters such as quality and layer thickness, infill percentage and type, and nozzle offset (3), indicating a sufficient grasp of how digital settings influence printed output. Accuracy checking is also evident through the use of calipers to measure output dimensions and compare these to CAD data. The identification of a 1 mm discrepancy and a plausible explanation strengthen this evidence of accuracy monitoring (4). Risk management is evident through notes that identify key process risks such as filament issues, heating requirements, and warping or detachment from the build plate. Associated mitigations, bed cleaning, fit checking, ventilation, and periodic monitoring, provide further evidence of independent management of factors that influence print reliability (5). However, while the evidence includes visual checks and verification of scale (6), it does not reference or evaluate the product against a complete CNC output specification. Missing elements such as dimensional tolerances across multiple features, surface quality expectations, support removal criteria, or performance of bridging limit the evaluative depth to a low Merit level. Taken together, the evidence supports a boundary Merit judgement, as the overall technical depth is uneven, and optimisation decisions lack detailed justification. Stronger evidence could be achieved by including explicit machine parameters such as nozzle and bed temperatures, filament specifications, and clearly defined acceptance criteria for printed quality. These omissions, also noted in the teacher commentary, cap the level of evaluation at low Merit (7).

Low Merit

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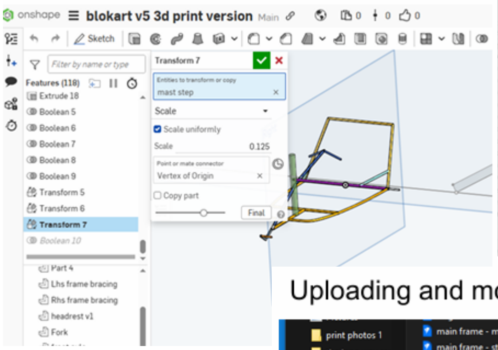
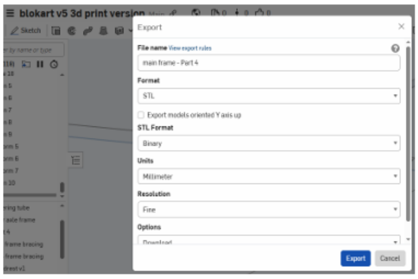
CNC

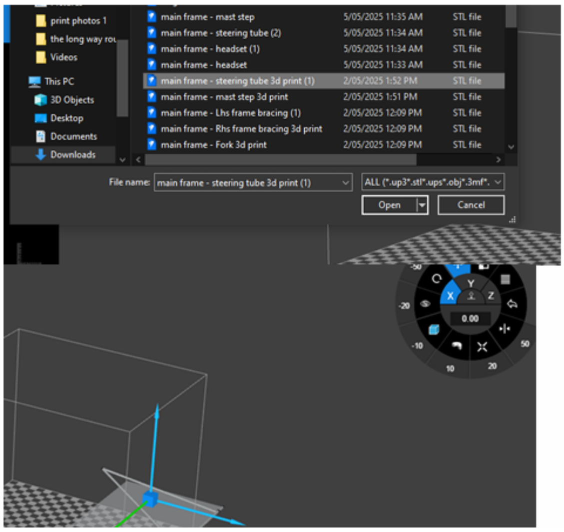
Making a graphical representation using the limits of the cnc machine.

1 To create a graphical representation suitable for the 3d printer I first took my onshape workspace (with the 3d cad model) and copied this. I scaled this version down using the transform tool so the largest part was under 200mm by 200mm by 80mm (the bed size of the big 3d printers at school). In the end I made it a bit smaller than this to save on time and printer filament. This is important as it minimises the scale of errors if they do happen ensuring efficient use of material. Next I needed to export each part as an stl file which is what the 3d printer requires. To do this you can simply press export part and then select stl file on onshape.



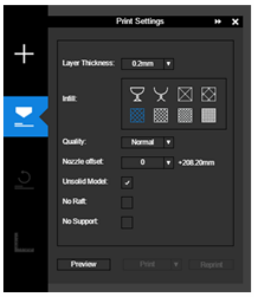


Uploading and moving file.

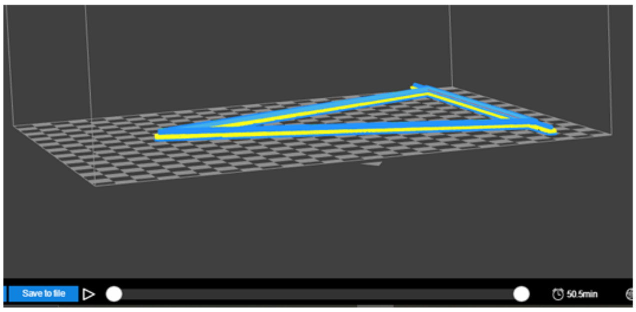


To 3d print something you first need to upload your stl file to the slicing software accepted by your 3d printer, in this case UP studio. Once your part is uploaded then most of the time it needs moving and rotating so it prints the fastest, and uses less filament as it requires less support. This is important as it helps keep printing within the timeframe not requiring teachers to be present at odd hours so the 3d printer can keep printing. This also minimises waste material . 2

Preview of print and settings



Once you are happy with the position of the print you can press print. This pops up a window showing the print settings which for my purposes default was fine. However if you were making a mold or something requiring extra strength this is where you can change infill which determines how solid the model is. You can also change the quality, layer thickness, infill, infill type, the amount of support and nozzle offset. Here is what each of those settings do: ***Quality :*** changes layer thickness and width which affects the smoothness and level of detail also changes speed of printing time, ***layer thickness :*** this changes the quality (detail, smoothness) of the print far more precisely than the quality setting as it allows your to change the layer height values rather than just have 4 setting of quality when changing the quality setting. ***Infill :*** This is how solid the model is. For example if you are just making a prototype, the default setting is ok as it doesn't have to be especially strong and you can economise of time and filament. If you are making gears for example that are to be used in a product then having more infill would be beneficial. ***Infill type :*** This controls the pattern of the infill which affects the density. Similar to the percent of infill this controls how strong the print will be and should be used in conjunction with it. Making sure you get the settings right is important to ensure the outcome/print is of a high quality standard.



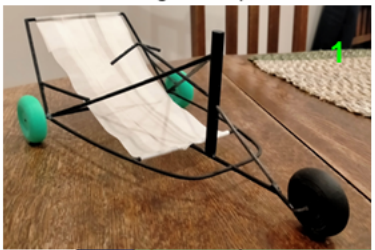
Once the settings and position of your model are satisfactory, you need to initialise the printer. This means the printer ensures it knows it's coordinates and is ready to print. Following this you preview your print which shows you the tool paths and where there will be fill. It also shows you how long the print will take and how much filament, which is helpful to ensure not using excessive resources. If you aren't happy with the preview, for example it will take too long, then go back and check the position and the settings. 3

Printing procedure and troubleshooting.

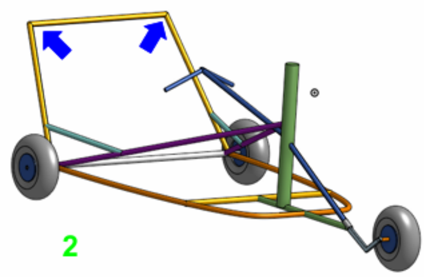
Once the print settings and preview are as desired the printer is ready to print. Before pressing print make sure there is enough filament (abs in this case) to avoid only getting halfway through a print. Once you have pressed print, the printer bed will take a while to heat up so the print doesn't warp off of it. This is indicated by the white temperature icon. The nozzle also has to heat up which is indicated by the red temperature icon. After this it will start printing and doesn't require constant attention and you can unplug your computer from the 3d printer. However it is good to check on your print every so often incase it has warped off the bed or become unstuck so you avoid wasting time and filament. Some of the causes of this is the bed not being fitted correctly or not being clean. These are things you should check if your print has failed before trying again after considering your settings again. Once your print has finished you can take the bed out of the printer and scrape/lever your print off the bed. Following this you can separate the part from the support material. Now you can measure your part or test fit it with other parts to make sure it is as desired. The key things for an efficient 3d printing process is only making your print quite small and making sure it is oriented so that it has the least support required to keep it up whilst having a large area on the bed to reduce the chance of warping and wasting a print. Well our printers are pretty safe as we are working with safer filaments it is important to be aware of the risks involved such as getting burned by the hot bed, inhaling to much fumes (although our printing filament is relatively safe fume wise) and the fire risk posed. Some strategies to mitigate these risks are: waiting for the printer to cool before getting your print out and making sure the ventilation is on (fans in the printing room) along with minimising exposure by checking on a print through the front window instead of opening the top lid. To manage the fire risk you should not leave the printer completely unattended, while you don't have to watch it print, someone should be in the ptec block when the 3d printer is running e.g make sure you don't leave it running over night.. 5

30

Assessment against specification.



Comparing image one to image two, I would say my cnc model is an accurate representation of my graphical representation. Along with this I could use tape to model what will be the fabric seat of my blokart which I was unable to model on CAD. To check my cnc product aligned with my second cnc specification; that it must be a consistent scale, I measured multiple components. As the scale is 8.3 to one, I then multiplied this measurement by 8.3 and checked it against my cad model. Doing this for my measurement of the mast step shown in image three, I found that this lead to the calculated size being 61mm which is 1mm off the 60mm it should be shown in image 5. This could have been off because the 3d printer printed it too large but I think in reality I just needed to push the calipers together with more force as the measurement only needed to be 0.12 of a mm smaller to give the right calculated diameter. To make sure the scale was consistent throughout I also measured along the top bar indicated by the two blue arrows on image 2. This was quite tricky to line up so I found it easier to get the calipers on the corners and then press zero. After this I could return it to zero and find the difference and thus the length. This measurement as shown in image 4 once multiplied by 8.3 gives 726.66mm which I would say is close enough to the 727mm it should be. Due to these measurements I believe my cnc model meets the specification of being a consistent scale. 6



31

xxxx you have given this a good go but I think you are missing some depth in areas. For example, you don't discuss What temperature the bed and nozzle need to be preheated to, you don't discuss initializing the printer and what this does And I'm not sure if the 3D Printer has default settings, just what someone previous used. I would have loved to see a 3D printing specification that you would then evaluate against. You have discussed enough of the relevant points to get an achieved.

7

Grade: High Merit

For Merit, the student needs to skillfully implement complex procedures to make a specified product using a Computer Numerical Controlled (CNC) machine.

This involves showing independence and accuracy in undertaking the procedures.

Evidence (1) indicates that the CNC machine was set up and operated independently, with the teacher's comment confirming this level of autonomy. Further evidence of independence appears in screenshots showing zeroing offsets and the import of G-code into CNC.js (2), demonstrating control of the workflow without prompted support.

Accurate CNC setup and toolpath configuration are shown through documented measurements for the T6 and T10 bits (3), indicating attention to correct tooling requirements.

Troubleshooting skills are demonstrated within the machining process. When the thumb holes did not cut through during an earlier machining pass, the evidence (4) shows identification of the cause and an adjustment from the original contour toolpath. Evidence from a final test route (5) further demonstrates refinement and problem-solving prior to committing to the full machining of the steering wheel, indicating controlled and iterative accuracy improvements in the CNC process.

Evaluation evidence (6) offers a concise but accurate comparison between the final product and the CAD model, noting bore-hole spacing, smooth edges, correct toolpath execution, and ergonomic considerations. Additional comparison images (7) show that board movement caused errors in an earlier attempt, which were addressed in route 2 by increasing clamping and correcting the retract height. This visual documentation demonstrates the ability to assess machining accuracy, identify causes of error, and implement corrective measures—key aspects of skilful implementation at the Merit/Excellence boundary.

To reach Excellence, the outcome must show not only independence and accuracy but also efficiency and a high level of finish without inconsistencies. Excellence requires evidence that CNC procedures were carried out in an economical and strategic manner, such as optimised toolpaths, minimised material waste, reduced re-cuts, and deliberate material layout choices. The process needs to be purposeful and streamlined rather than reliant on trial-and-error, with explicit commentary on how these decisions improved efficiency and contributed to a refined, accurate final product that aligns with the specifications and the graphic representation.

The teacher comment explains why the evidence does not reach Excellence, noting that the evaluation required strengthening, that accuracy in the machining route could be improved, and that the explanation of efficiency, tooling decisions, and material-use justification was not yet at the depth required for an Excellence judgement.

High Merit

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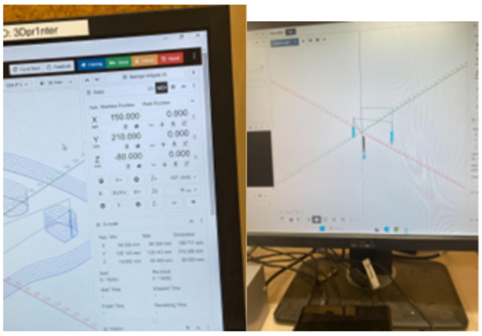
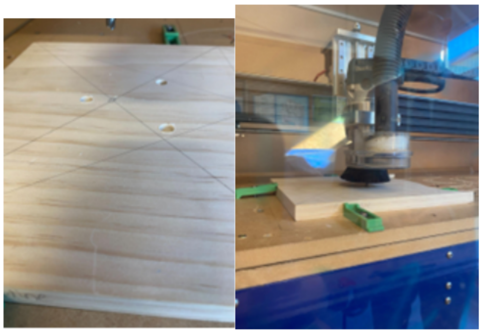
MARK OVERALL GRADE	N ☐	A ☐	M ☑	E ☐	Comments: high merit. XXXX showed capabilities with the CNC router. He was independent with it and could set up and use it safely. He needed to strengthen his evaluation, improve a little with accuracy of the route, and also the description of the efficiency/tooling/material wastage.



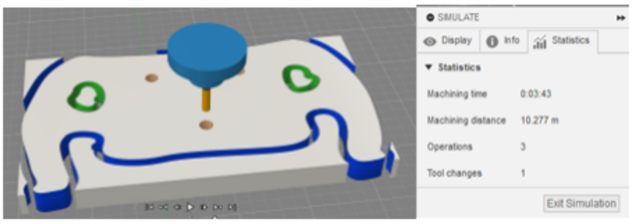
CNC.js
- Zeroing offsets before routing (left photo)
- Showing copied g code into cnc.js program (had to upload it as a NC program using vertigo postprocessor)



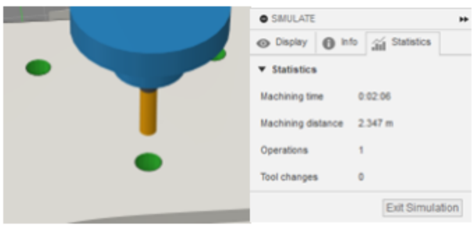
Routing
- Bore holes after routing with the cnc machine (left photo)
- Bore holes during routing with the cnc machine (right photo)

Measurements of tool bits used

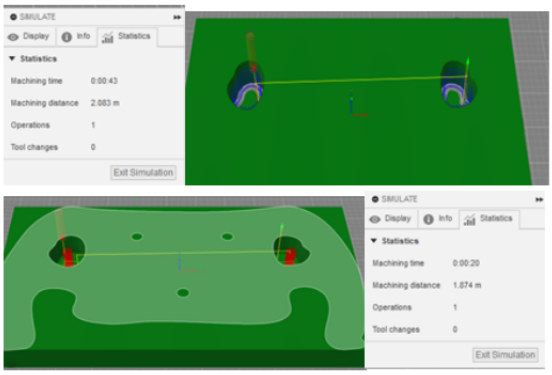
T6: width 6mm flute length 20mm overall length 60.1mm
T10: width 6.35mm flute length 25.4mm overall length 63.5mm



Paths (simulation)
- Stats for all tool paths (bore holes, thumb holes, outline. Not including time per tool change)
- CAM simulation of board after simulation



Bore holes
- Stats for the holes (no tool changes were needed as it was the only tool path
- Bore holes after CAM simulation

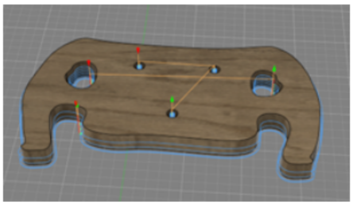


Thumb hole testing
- Thumb holes didn't drill through. To fix this I changed the type of tool path from 2D pocket to 2D contour
- Stats for the 2D pocket and 2D contour (2D contour made the finale design)

Test route:

	
Final test route - Hole cut out (2D contour practice) - Measurements (Width, length, height) - Engrave (needed two different tool bits and tool paths) 5	Fusion CAM final test route - Stats (time, distance, tool, etc.) - Board during simulation - Board after simulation

FINAL CAD DESIGN

	
Final renders of steering wheel - Has thumb holes - Has space for fingers to wrap around the wheel - No sharp edges 6	Tool paths - Shows bore hotels - Thumb holes - Outline of the wheel - Green arrows (where the tool bit raises) - Red arrows (where the tool bit goes descends)

 7	
Route one - I didn't add a retract height for the bore holes - Cut through the board - Thumb holes are off due to the board moving slightly while routing - Good outline	Route 2 (result) - Bore holes had a safe retract height and didn't go through the board sideways - Added more clamps to stop the board from moving - Backside is not as splintered as the first route

My final outcome meets the parameters and specifications; it does not have jagged or sharp edges; it has three 10mm bore holes each 40mm from each other or 120 degrees from each other. It may not be a generic steering wheel, but it is a f1 wheel giving me more room and space for possible error. Since we used wood, the wheel has a small amount of flexibility but is still rigged and strong. Both hands also fit comfortably while holding the steering wheel. I used two different tool paths and two different tool bits to make my route; this also meets the cnc specifications.

Overall, the look at design of my wheel is aesthetically pleasing; I have had little to no bad feedback and overall follow specifications well. I was first on the router because I wanted to get comfortable with it so I could use the cnc as effectively and efficiently as possible. My total route time (minus tool changes) was 3 minutes and 43 seconds. This was a good time because it meant I could take a little longer on tool change. The final route took minimal effort to complete as all I had to do was send my code to the computer and clamp it down. I chose my tools with appropriate flute length, so it didn't burn the wood, I used a tool bit with a smaller diameter to make the bore holes the right size. I chose to make my f1 wheel rectangular because I could put it sideways and close to the edge of my stock so I could get the most out of the piece of wood I was given, so I could minimize the amount of waste product left over.

Low Excellence
For Excellence, the student needs to efficiently implement complex procedures to make a specified product using a Computer Numerical Controlled (CNC) machine. This involves undertaking procedures in a manner that economises time, effort, tooling, and materials. Across the sample, the workflow demonstrates that procedures were undertaken in a way that economised time, effort, tooling, and materials alongside independence, consistent accuracy, and informed decision-making. Multiple test cuts and engravings were carried out to determine optimal cutting speeds, engraving speeds, and power settings. The evidence explicitly states that this testing process avoided re-cuts and prevented material waste, directly showing economy of time, effort, tooling, and material. These actions align closely with the Excellence expectation for efficient implementation. Further evidence (1) demonstrates that machine parameters were adjusted to optimise quality, indicating purposeful problem-solving rather than basic completion of tasks. Test outcomes were evaluated, and refinements were made to reduce material waste, improve cut quality, and preserve usable stock. This reflects deliberate efficiency in the management of CNC processes. Additional evidence (2) shows that the chessboard was designed first, an approach that reduced the likelihood of re-cutting pieces. By establishing accurate dimensions early, the subsequent piece production process was streamlined, and the risk of wasting time due to limited CAD experience was minimised. Understanding of CNC laser limits is also integrated throughout the workflow. Evidence (3) shows that starting points were selected to minimise waste, and template-based approaches were used to ensure consistency and prevent rework. Designing a custom cutting template (4) further reduced the risk of alignment errors and accelerated production by maintaining consistent positioning across repeated cuts. These decisions demonstrate a sustained focus on reducing both material consumption and processing time. The evidence also shows iterative cycles of testing, evaluating, refining, and implementing, which collectively demonstrate efficient management of complex CNC procedures. For example, pieces were grouped and rotated to maximise use of the available board area, reducing off-cuts and avoiding wasted material (5). This nesting behaviour is a clear indicator of efficiency within the workflow. Overall, the sample crosses the Excellence threshold because it shows multiple instances where procedures were implemented efficiently. To secure the grade, the evidence would need to make these efficiencies clearer and more comprehensive across the full process. For example, briefly logging defect-prevention actions and the defects avoided, justifying the cut order (engrave before cut to avoid movement, thin features last), including nesting screenshots with yield calculations, and/or documenting machine bookings met without overrun. Some aspects of efficient practice are implied rather than explicitly demonstrated.

Low Excellence

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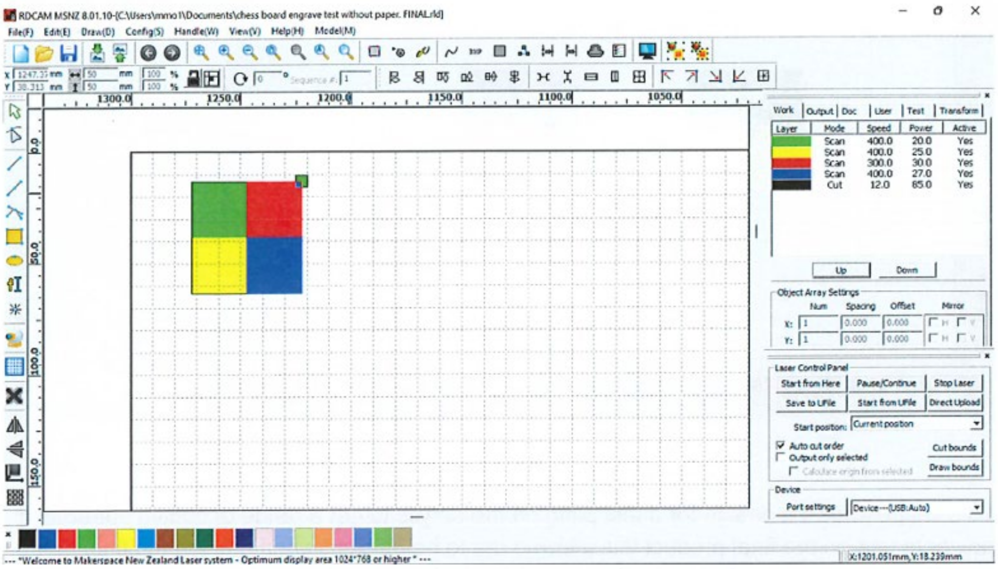
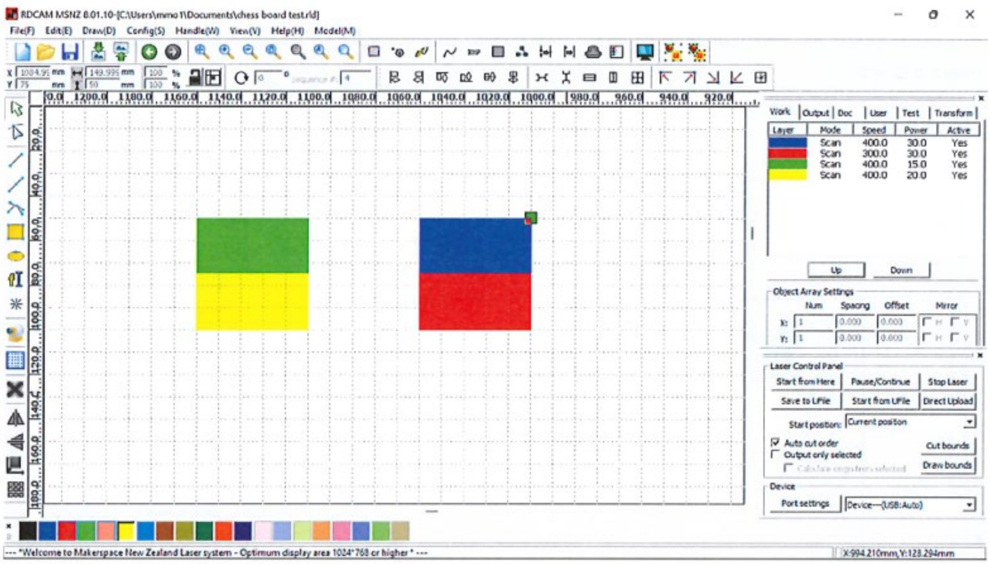
The laser cutter measures from the top right corner so I had to make sure that if there was room, I minimised material waste I moved the nozzle as far to the right and up that I could. I then had to pick my engraving speed and power as well as make sure the cutting speed and 1 power were right. For cutting the 6mm wood I used a power of 75 and a speed of 15, for the 3.2mm wood I used 30 speed and 60 power, for cutting acrylic I used 12 speed and 85 power but after a few cuts, it was found that lowering the power to about 70 would warp pieces less and leave a better cut.

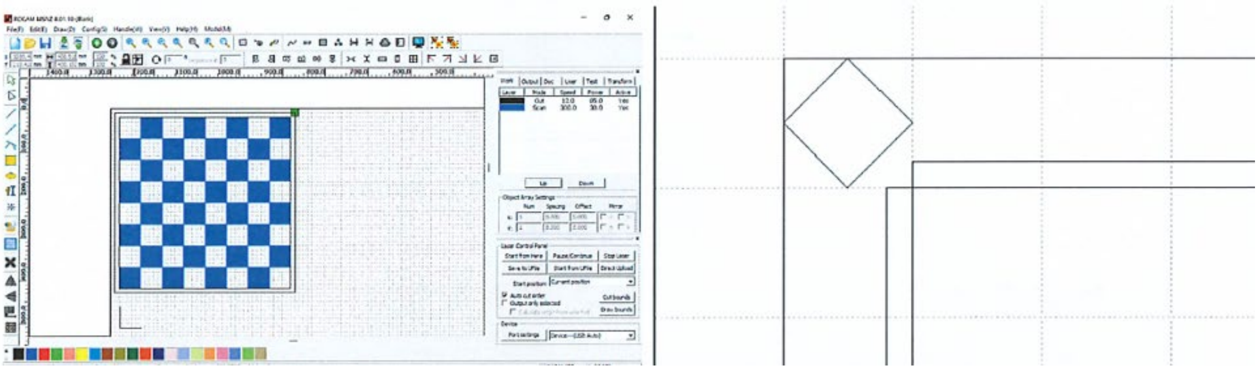


The image above shows the first test I did for engraving speed which had a large range of powers to get a rough power that I could then fine-tune which I did in the image below

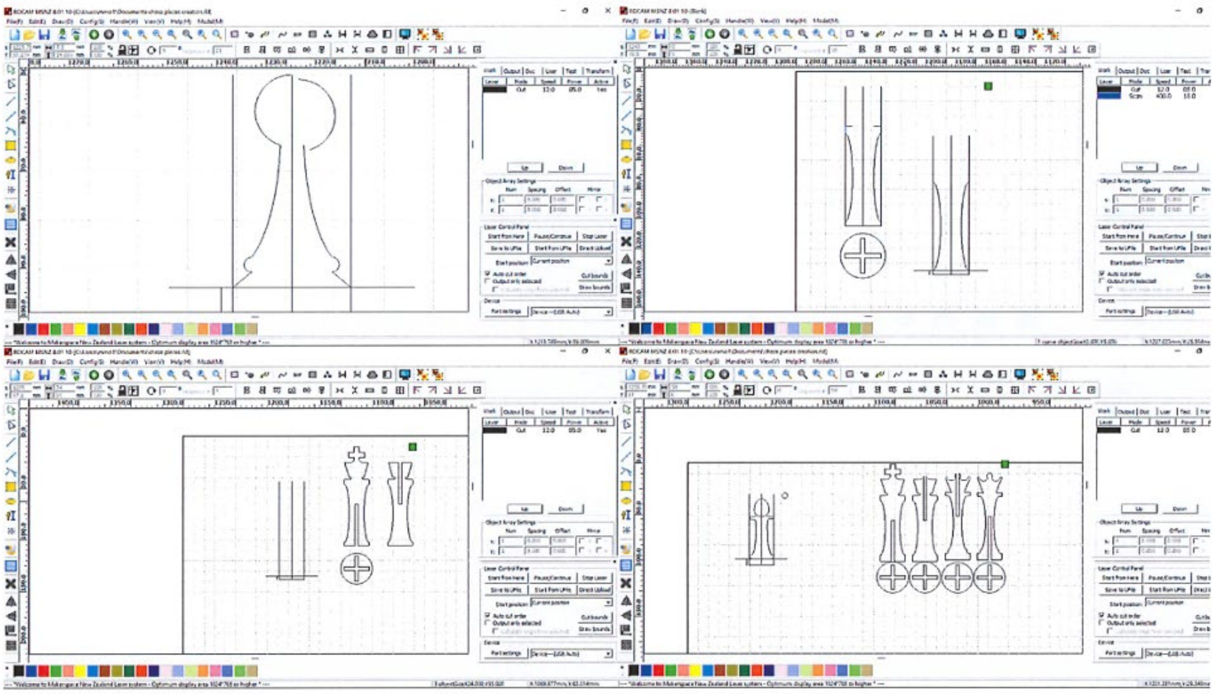


This image shows a design for a test plate on the acrylic to get a range of cutting speed and power to use on the final product this allowed me to be efficient when making the final board because I knew I wouldn't need to re-cut anything since I had already tested all the engraving speeds and my grid sizing. This test cut uses lower powers than the one above it because when I used higher powers to engrave the engraved area was quite rough and cut down deeper than I wanted, the rough texture wasn't welcome because I was wanting the cutting to only shade in the alternate squares.

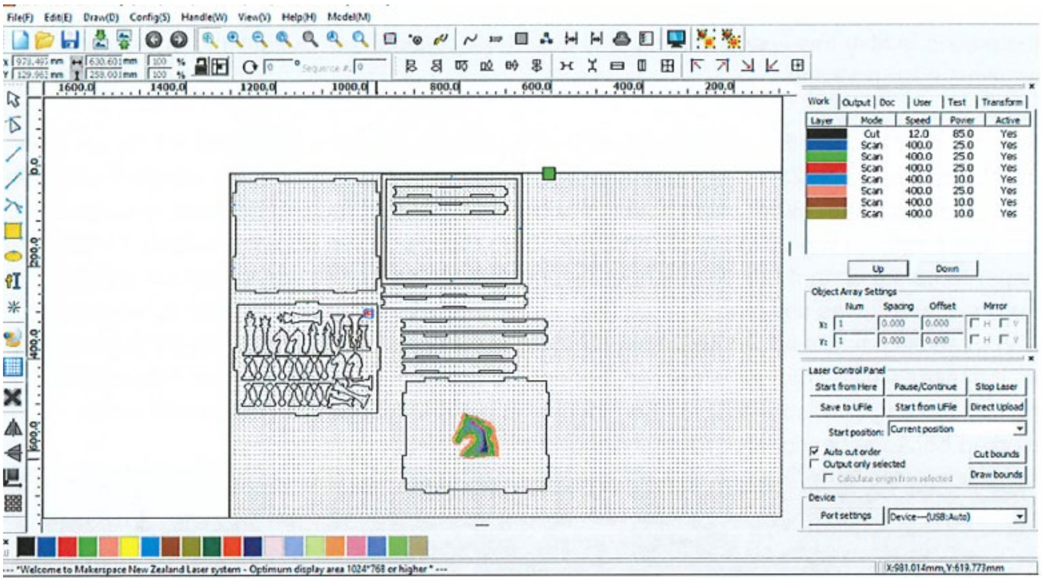
I decided to start with designing my chess board because it will set the size of my chess pieces and was the easiest part of the design which would allow me to get used to the CAD software so when I start designing my chess pieces I would have more experience and a better ability to shape them as intended. Making the chess board first also allowed me to decrease the amount of re-cutting I would need to do if, for example, I made the chess pieces first and later found out they weren't the right size, compared to the chessboard. 2



3 While making the first few chess pieces on the CAD program I thought it would be better if I made a template that I could scale to the size of my pieces while designing them so I used a series of lines to show the sides, centre and base thickness to allow better accuracy when designing the pieces and other utility lines that I used for aligning parts of the piece.



The images above show the designing process using the template that also stopped parts of the chess piece exceeding the width of the base. This template also allowed me to make the pieces quicker because I was able to align parts to the lines on the template. After I had designed and cut out the chess pieces I put them in a lathe and sanded down each of the bases to get rid of any extra glue using the template also helped me have confidence in the fact that each piece was aligned with the same as the rest, it also allowed me to quickly and efficiently make new pieces. The king's height is 95mm, the queens 85mm, the bishops 70mm, the knights 60mm, the rooks 55mm and pawns 50mm. The bases of the pieces were all 30mm except for the pawn which is 26mm wide. 4



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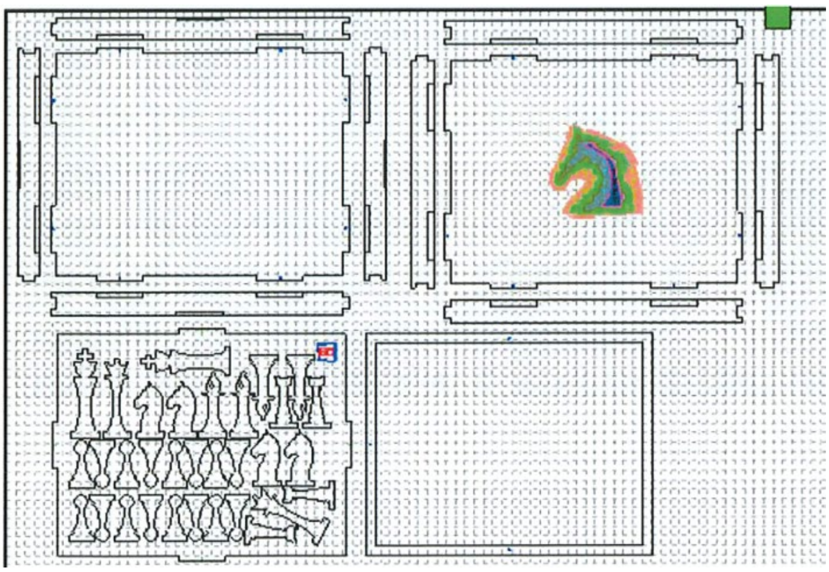

The first image above shows how all the pieces looked when it came to cutting the case out. All the pieces were cut on 6mm thick wood apart from the piece that holds the chess pieces that were cut at 3.2mm. The horse was engraved in 4 different layers increasing the depth of the burns each time, before cutting the horse into the box I did i smaller test on an individual piece of wood to ensure that everything was working as intended. The second image shows everything grouped with the parts they're to be assembled with, I moved the parts to be like this so that I could ensure everything was aligned correctly and that there were no sizing issues. The hole for the chess pieces to sit in is in some cases rotated, this is to allow all of the pieces to fit in this space making it so I use less material and overall end up with the smallest case possible.