# Process Plan Setup Sheet (Stage II)

| | | | | | |
|---|---|---|---|---|---|
| Company | University of Auckland | | Workshop | Manufacturing Systems Lab | |
| Data/Time | 28/09/2018 16:00 | | Machine | ManSys1 | |
| Material | Cast Iron | | Programmer | Group: | 6 |
| | | | | | |
| Stock Size | See Attachment 2 | | *Your signatures: | | |
| Units | mm | | | | |

* Signing here means that you have read the following declaration.

"I have read and understood the Engineering Policy on cheating in the Handbook, and hereby declare that all parts of this assignment are my own work. In particular, I have not received any excessive help from anyone and I have not given any excessive help to anyone. I understand that if all or part of my hand-in is found to be suspiciously similar to anyone else's then both of us will be suspected of cheating and will be interviewed by the Dean."

For Stage II submission, please fill the following table.

| Group member | Name | ID | Contribution percentage | Signature |
|---|---|---|---|---|
| 1 | Alex Melia | 827525579 | 33.3 % | |
| 2 | Matthew Oates | 8755141 | 33.3 % | |
| 3 | Devdass Krishnan | 719113833 | 33.3 % | |

| Setup # | Setup Orientation (-X, -Y, -Z, +X, +Y, +Z) | Operation Name | Feat. # | Feature | Roughing or (Semi-) Finishing | Tool Name | Tool Diameter mm | RPM 3 S.F. N | Feed Rate Vf mm/min | Step Depth ap mm | Step Over ae mm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | +Z | Top_Face_Rough | 1 | Top Face | Roughing | Face Mill | 50 | 3509 | 4211 | 3.8 | 25 |
| machining time for **set-up 1**: 1.064 minutes | | | | | | | | | | | |
| 2 | -Z | Bottom_Face_Rough | 2 | Bottom FacTotal e | Roughing | Face Mill | 50 | 5410 | 6492 | 2.8 | 22 |
| | | Bottom_Face_Finish | 2 | Bottom Face | Finishing | Face Mill | 50 | 10000 | 6000 | 1.2 | 25 |
| Total machining time for **set-up 2**: 1.21 minutes | | | | | | | | | | | |
| 3 | +Z | Top_Face_Semi-Finish | 1 | Top Face | Semi-Finishing | Face Mill | 50 | 10000 | 6000 | 1 | 25 |
| | | Top_Face_Finish | 1 | Top Face | Finishing | Face MIll | 50 | 10000 | 3000 | 0.2 | 25 |
| | | Clamping_Hole_Rough | 3 | Clamping Holes | Roughing | Twist Drill | 18 | 1600 | 140 | - | - |
| | | CH_Counterbore_Finish | 3 | Clamping Holes | Finishing | Slot Drill | 15 | 4290 | 170 | 20 | 3.5 |
| Total machining time for **set-up 3**: 7.47 minutes | | | | | | | | | | | |
| 4 | +Z | Step_Top_Rough | 5 | Step | Roughing | End Mill | 40 | 10000 | 4020 | 2 | 10 |
| | | Side_Profile_Rough | 4 | Side Profile | Roughing | End Mill | 40 | 10000 | 4020 | 20 | 2.8 |
| | | Side_Profile_Finish | 4 | Side Profile | Finishing | End Mill | 40 | 10000 | 2010 | 20 | 1.2 |
| | | Step_Profile_Rough | 5 | Step | Roughing | End Mill | 40 | 10000 | 4020 | 20 | 2.8 |
| | | Step_Profile_Finish | 5 | Step | Finishing | Slot Drill | 10 | 10000 | 190 | 10 | 1.2 |
| | | OPWB_Rough | 6 | Open Pocket With Boss | Roughing | Slot Drill | 10 | 2110 | 80.2 | 10 | 10 |
| | | OPWB_Finish | 6 | Open Pocket With Boss | Finishing | Slot Drill | 10 | 10000 | 190 | 10 | 1.2 |
| | | Slot_Rough | 8 | Slot | Roughing | Slot Drill | 10 | 2110 | 80.18 | 10 | 10 |
| | | Open_Slot_Rough | 9 | OpenSlot | Roughing | Slot Drill | 10 | 2110 | 80.18 | 10 | 10 |
| | | Compound_2_Rough | 11 | Compound Hole 2 | Roughing | Slot Drill | 10 | 1400 | 53.2 | 15 | 10 |
| | | Tee_Slot _Upper_Rough | 7 | Tee Slot | Roughing | Slot Drill | 15 | 1670 | 66.8 | 12 | 15 |
| | | Compound_1_Rough | 10 | Compound Hole 1 | Roughing | Slot Drill | 15 | 670 | 26 | 30 | 15 |
| | | Compound_1_Counterbore_1 | 10 | Compound Hole 1 | Finishing | Slot Drill | 15 | 4000 | 160 | 15 | 5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tee_Slot _Lower_Rough | 7 | Tee Slot | Finishing | Side Mill | 32 | 385 | 120 | 11.2 | 32 |
| | | Compound_3_Rough | 12 | Compound Hole 3 | Roughing | Twist Drill | 8.5 | 3500 | 145 | 30 | - |
| | | Compound_3_Tap | 12 | Compound Hole 3 | Finishing | M10 x 1.5mm Tap | 10 | 60 | 90 | - | - |
| | | Compound_4_Roughing | 13 | Compound Hole 4 | Roughing | Twist Drill | 9.85 | 3000 | 140 | - | - |
| | | Compound_4_Finish | 13 | Compound Hole 4 | Finishing | Reamer | 10 | 50 | 1 | 1 | - |
| | | Compound_5_Roughing | 14 | Compound Hole 5 | Roughing | Twist Drill | 38 | 940 | 100 | - | - |
| | | Compound_5_Finish | 14 | Compound Hole 5 | Finishing | Borer | 40 | 600 | 25 | - | 2 |
| | | Circular_Slot_Rough | 15 | Circular Slot | Roughing | Side Mill | 36 | 215 | 150 | 3.5 | 2 |
| | | Compound_2_Chamfer | 11 | Compound Hole 2 | Finishing | Countersink | 25 | 1200 | 52 | 1 | - |
| | | Compound_3_Chamfer | 12 | Compound Hole 3 | Finishing | Countersink | 25 | 1200 | 52 | 1 | - |
| | | Compound_4_Chamfer | 13 | Compound Hole 4 | Finishing | Countersink | 25 | 1200 | 52 | 1 | - |
| | | Compound_5_Chamfer | 14 | Compound Hole 5 | Finishing | Countersink | 50 | 600 | 75 | 1 | - |
| | | Compound_1_Chamfer | 10 | Compound Hole 1 | Finishing | Countersink | 50 | 600 | 75 | 1 | - |
| Total machining time for **set-up 4**: 62.63 minutes | | | | | | | | | | | |
| Total machining time for **all setups**: 72.4 minutes | | | | | | | | | | | |

# Process Plan Explanation

Stage 1 of task 3 required us to work individually to create an NC process setup. Since then, we have consolidated our ideas and priorities (eg; time vs precision, appropriateness of the selected tool etc) and formed an NC process plan collaboratively.

Our process plan is comprised of 4 setups. Each setup is orientated in either the +Z or -Z axes as we found no need to use any other axis in order to fully machine each feature in the design.

It is not sufficient to rely solely on the table clamps when machining the part - in order to fully machine each feature of the part, clamping holes are required to secure the part to the machining table. Setups 1 to 3 (inclusive) are allocated to roughing and finishing the bottom and top faces and producing clamping holes in the part in order to appropriately prepare the part for the rest of the features to be machined into it.

**Setup 1:**
**Orientation: +Z**
It is hard to ensure accurate tolerancing without establishing a datum with reference to a surface that isn't roughed. For this reason, the Top Face is roughed in with a 50mm Face Mill to provide a surface accurate enough to act as a datum when performing operations in setup 2; this tool was chosen for its high material removal rate.
Even though the top face was chosen to have a roughing, semi-finishing, and finishing cut, only a roughing cut was taken in setup 1 because taking finishing cuts from a surface that doesn't have a roughed surface as a reference datum may introduce inaccuracies in how our tolerances are produced.

**Setup 2:**
**Orientation: -Z**
The Bottom Face is roughed and finished to the required tolerance with the same 50mm Face Mill as used in the previous setup. After roughing the bottom face, it is now appropriate to finish the top face surface since a machined datum has been established - it can now be used as a reference for machining features with tolerances.

**Setup 3:**
**Orientation: +Z**
The Top Face is brought in to specification with semi-finishing and finishing operations, both with the same 50mm Face Mill. The Clamping Holes and their counterbores are formed first by drilling out the 18mm through hole with a Twist Drill, then forming the counterbore with a 15mm Slot Drill.

**Setup 4:**
**Orientation: +Z**
The part is taken out of the machining clamps that it was being secured by in setups one through three and is now clamped down using the Clamping Holes created in setup 3. This allows access to all the features yet to be formed and sufficient security in order to perform the rest of the machining sequences.

With the part clamped securely using the Clamping Holes, the top of the step is roughed 40mm face mill so that it does not damage the finish of the side profile. The Side Profile of the part will be machined using a 40mm End Mill. This tool will also machine part of the Step's profile. The 40mm End Mill was selected for this as it has a relatively high material removal rate and will be able to perform the required operations in fewer passes than the larger 50mm cutter as the 40mm cutter has a larger maximum step depth, allowing for fewer steps to complete the operation.

In order to finish the Step a 10mm Slot Drill will be used to bring the profile of the step to final specification, due to the 10mm inner diameter of 2 of the corners in the step profile. The tool has a lead in distance in this operation to avoid leaving small lumps of material. This tool will also be used to form the Slot, Open Slot, Open Pocket with Boss, and Compound Holes 2. These operations are grouped together to reduce the number of tool changes. The 10mm Slot drill was selected because of its efficiency when used in the manner described above, and because of a few corners with inner radii that limit the diameter of the tool used. It is also able to plunge directly into the work.

Next, the Tee Slot will be formed using a 15mm Slot Drill to create the leg of the tee. This tool will also be used to drill Compound Hole 1 and to create this hole's counterbore. The leg of the tee was cut 2mm too deep, so that no small burrs were left over after the side cutter completed the cross of the tee due to slight depth inaccuracies. A 32 x 14mm Side Mill will form the cross of the tee. The next feature to be formed will be the threaded hole Compound Holes 3, which will be done using an 8.5mm Twist Drill and M10 x 1.5mm Tap. Compound Holes 4 will be formed by first roughing out the hole with a 9.85mm Twist Drill, then reaming to the required 10mm diameter with a 10mm Reamer. This will produce the high quality surface finish required on this feature.

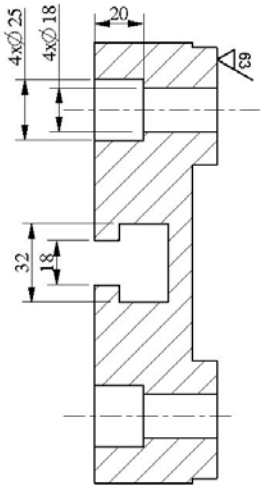
Compound Hole 5 is formed by first roughing out the bulk of the material with a 38mm Twist Drill, then boring out to final dimension with a 40mm Borer. This is done to create the precise surface finish required on this feature. The Circular Slot is then formed in the bore of this hole with a 36 x 3.5mm Side Mill. The final step is to form the countersinks and chamfers on the Compound Holes, this is done with a 25mm Countersink, used as a countersink on holes 1 through 4, then to mill the chamfer on Compound Hole 5. The countersink operations were grouped together, also to prevent unnecessary tool changes.

All counterboring operations used a small overrun distance to avoid leaving burrs/scrap material in the holes.

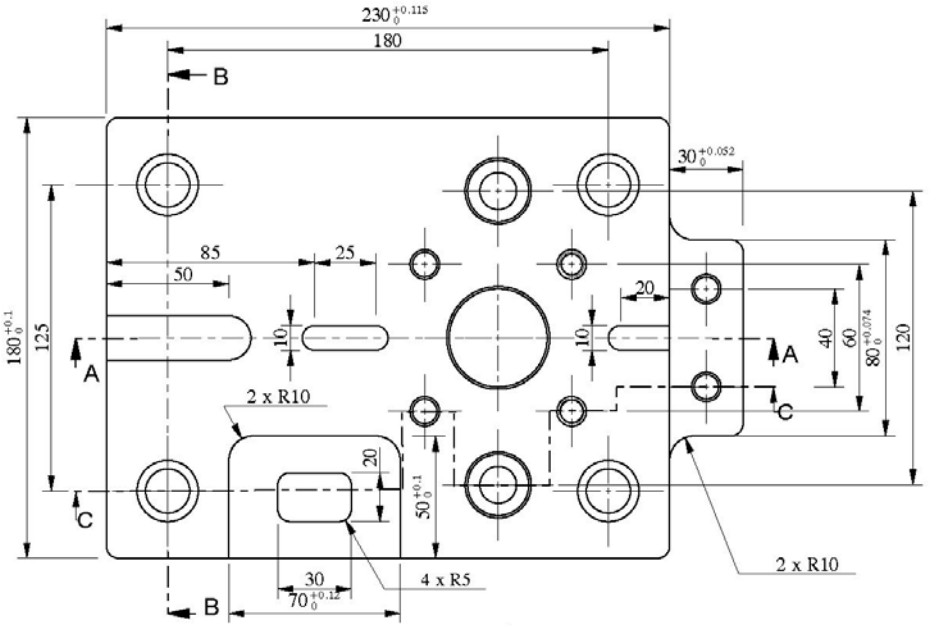
It should be noted that many sequences that require a common tool were grouped together in order to prevent unnecessary tool changes, reducing the time required to machine the entire part. This is visualised in our process plan using the light grey and grey colours. Eg; a feature may only be partially completed prior to performing a sequence on a different feature, because these sequences require a common tool.
It should also be noted that when grouping sequences together that use the same tool within the same setup, it is not necessary to return the tool to the home position as the tool is not being changed, however it does maintain a standard clearance of 5mm.

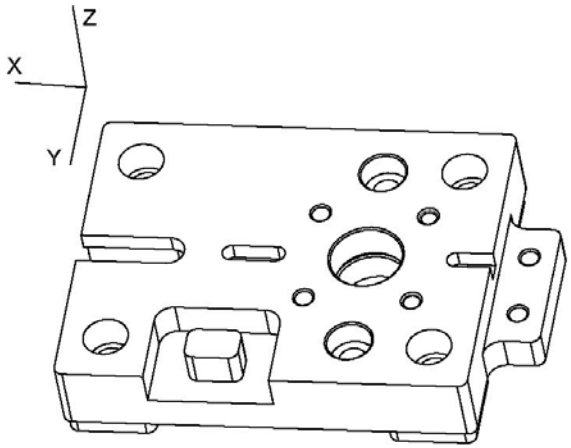
# Attachment 1 Part to Be Produced

All dimensions are in mm
All chamfers 1 x 45°
All rounds R5, unless specified
Tolerances ±0.5, unless specified
Surface roughness Ra 125, unless specified

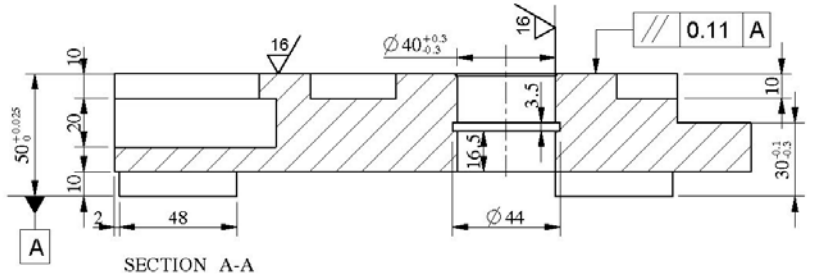



SECTION B-B

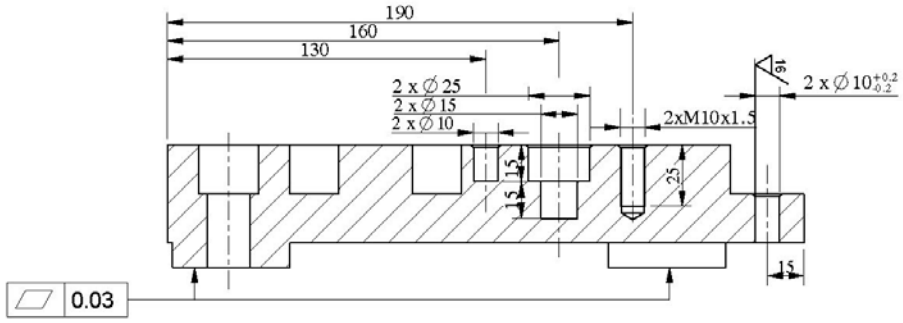



SCALE 0.300



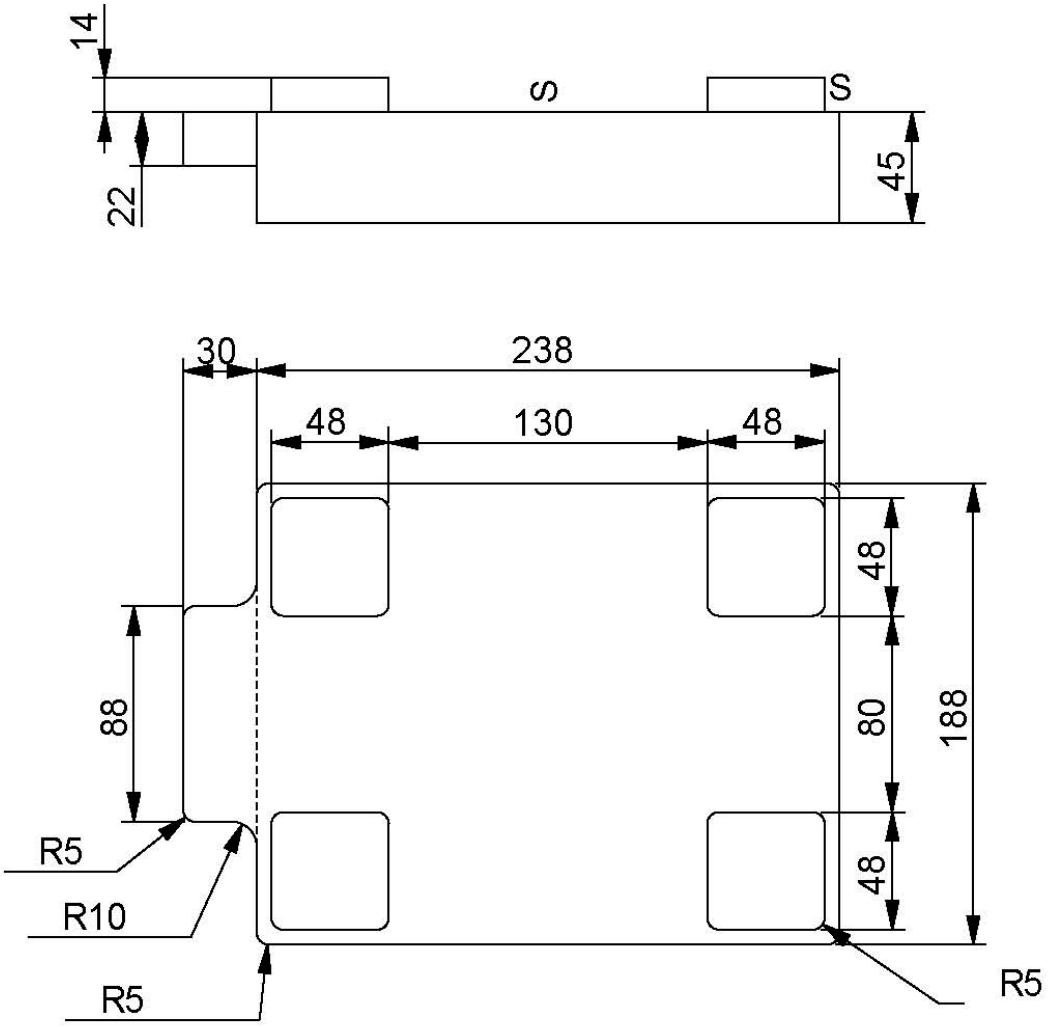

SECTION A-A

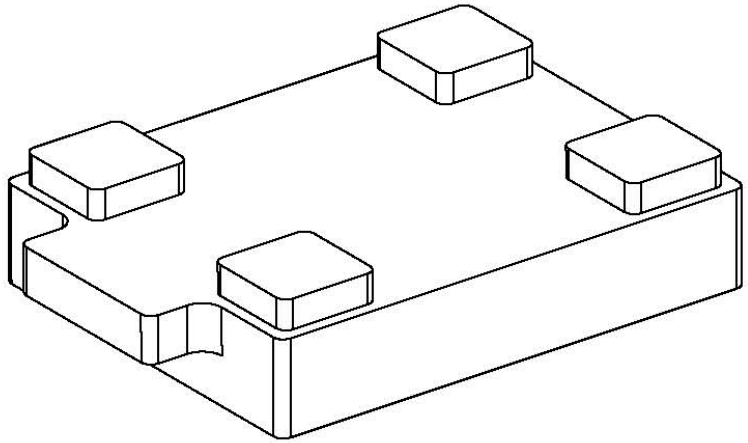



SECTION C-C

SCALE 0.400

## Attachment 2 The Stock (Cast Iron)



S - faces need not to be machined