ME 597 Lab Project
Project # 1: NC Part Programming and Machining on a 3-Axis CNC Machining Center

Lab date: **April 15 and April 16.**

Due date for submitting G-codes for Lab Instructor's review: **April 12, 12pm.**

Email to the Lab Instructor Scott Campbell (scott.d.campbell@oregonstate.edu).

Due date for lab reports: 1 week after the lab is finished.

Reports are submitted online by one of the group members on Canvas. Don't forget to include names of your group members on the title page of the report.

Grading

G-code submission for review	50%
Lab performance	50%
Total	100%

Introduction

The first step in machining a part on a CNC (computer numerical controlled) Machining Center is to generate the appropriate G-code that the NC system can accept. The NC code or so called the G-code contains the tool-path information where the cutter travels and removes material from the work-piece. The G-code also includes the process parameters such as federate, spindle speed, coolant usage or the tool data. This information is critical to achieve desired accuracy such as surface tolerances, efficiency or even avoid tool breakage. For instance, if the feed is selected too high, the chip load may break the tool. Or, high spindle speed may cause the work-piece material to melt due to high cutting temperature. These process parameters are generally selected by manufacturing engineers using information gained from handbooks or by experience. Finally, for the G-code to run on the NC system, it must contain the correct commands.

Tasks

A simple rectangular part made of HDPE (High Density Polyethylene) is given Figure 1. In this project, students are asked to machine a part of their own design on a 3-axis CNC milling machine. The generation of the NC program have to be **manually** done using the provided NC part program structure by utilizing the G-commands studied in the class. **(Manual programming is a must)**.

Please consider the following constraints while designing your part and G-code:

1. The blank work-piece is a rectangular block and has the dimensions given in Figure 1. It is fixed on a vise and datums are placed on the **left bottom corner**. In other words, the global coordinate frame, (0,0) point is fixed at the corner.
2. Please design your part within the given dimensions and leave 0.2 [inch] from the edges of the part for fixturing and safety.
3. The cutting tool has a diameter of d=1/4[inch] and it is a 4 flute solid end-mill. Please do not exceed the federate of F = 12.0[inch/min] in your part program.
4. Considering the fact that at first a plunging in the Z direction to the part will be performed, the feedrate should not exceed F=2.0[inch/min] in the Z direction.
5. For moving the tool down in the Z direction, use G0 to move the tool **0.25 [inch] above the part surface**, and then start feeding using G1 with the specified feedrate (F2.0).
6. Since there is only a single tool used in the process, tool magazine commands are not necessary.
7. Coolant is not necessary and not applied in this operation.

8. The total depth you are allowed to cut is ΔZ=1/2[inch]. Please do not exceed it.
9. Sometimes the surface of the work-piece is not flat due to fixturing and raw material. If you prefer, you can take some material from the top surface with smaller depth.
10. The Bridgeport NC system is utilized in this lab. Overall list of the G codes accepted in this NC system are given in this web page as reference http://www.helmancnc.com/bridgeport-g-code-list-cnc-mill/
11. An example part machined using this machine is shown in Figure 2.
12. Notice that G0, G1, G2, G3 commands can be programmed as G0, G1, G2 and G3. They are identical.
13. Always use decimal points for position and speed commands, even for integers. For example, instead of "G90 G1 X1 Y3 F2", use "G90 G1 X1.0 Y3.0 F2.0". Otherwise, your code will be interpreted incorrectly by the NC system.

Grading and Evaluation:

- Please design your part and the corresponding G-code.
- Every group must send their G-code to the lab instructor for review before **12pm noon April 12.** The lab instructor will check and provide feedback on the same day **by 5pm**. Based on the feedback make sure to correct errors before the lab. Groups that do not send their G-codes will get a penalty of 50%.
- The email addresses for the lab instructor is below. Indicate your group number and the session. *Scott Campbell: scott.d.campbell@oregonstate.edu*

- The designed tool-path must have both **linear and circular** interpolation for receiving full grade. *Please pay attention to the **circular** interpolation command usage in Bridgeport NC. G91 (incremental) programming is necessary to realize the I-J type circular interpolation. Otherwise, **R**(radius) command must be used. However, the Bridgeport controller demands the full circle to be separated into 2 arcs or more for **R** commands. Please see example G-codes in Figure 4.*
- A lab report must be prepared after the lab is finished. The machined part and the lab report must be submitted to the instructor for evaluation.

The lab report should explain steps in the generation of the NC code while presenting the feed direction and points. An example is depicted Figure 3. ***Please include a similar presentation in your lab reports. A figure of the machined path and a table of target points and the final G-code.***

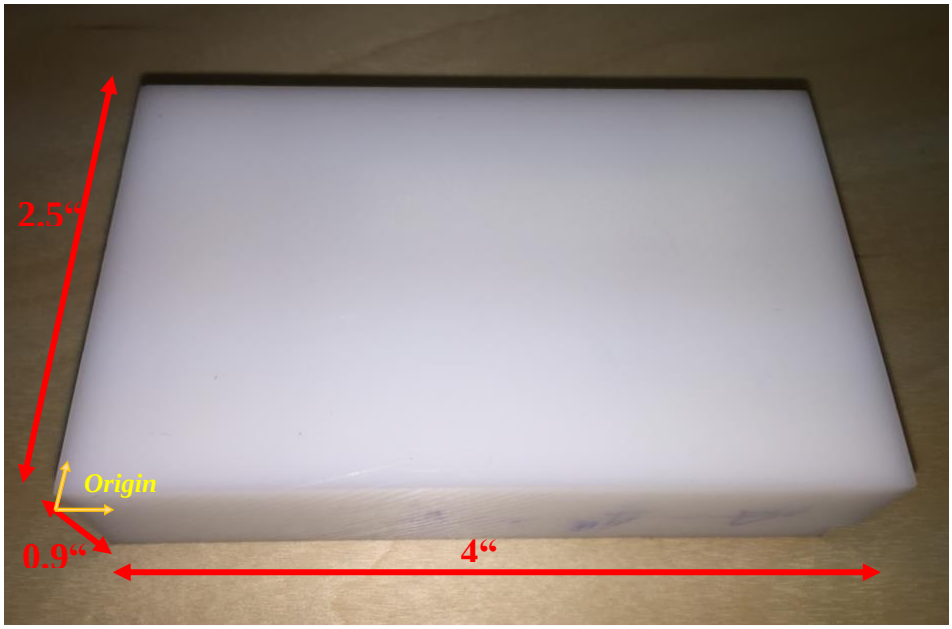


Figure 1: Blank Work-piece and dimensions

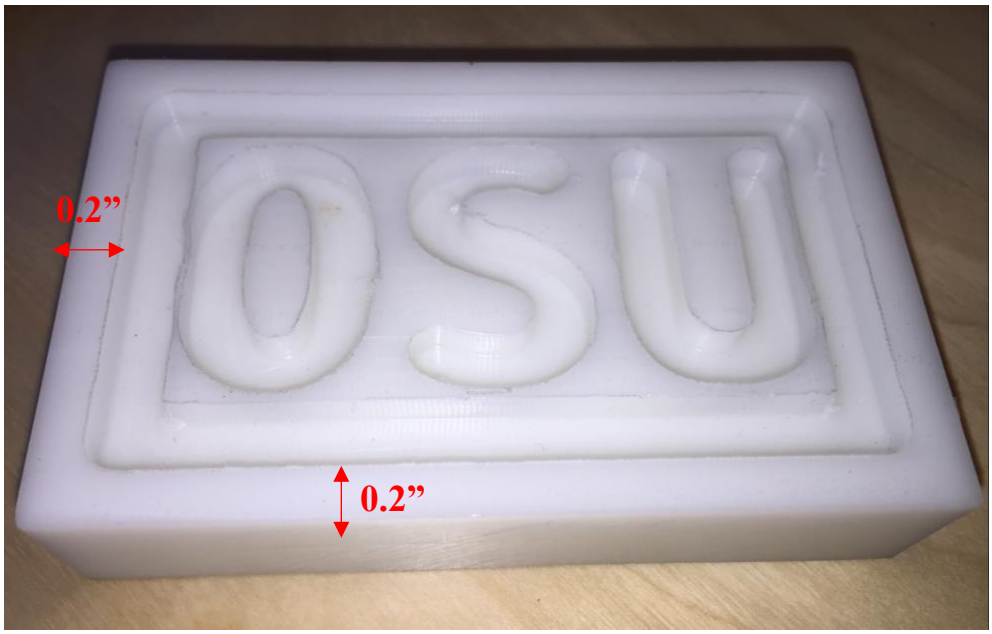
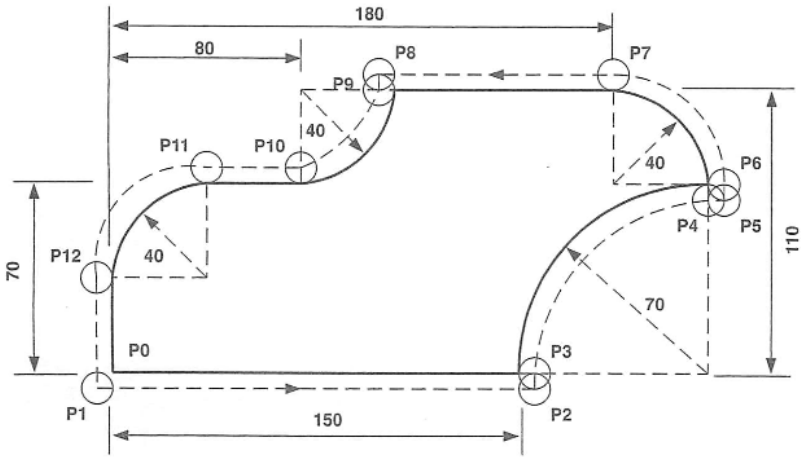


Figure 2: Example Finished Work-piece



Points	X	Y	Circle center
P0	0	0	
P1	-12.5	-12.5	
P2	-162.5	-12.5	
P3	-162.5	0.0	
P4	220	57.5	c(220,0)
P5	232.5	57.5	
P6	232.5	70	
P7	180	122.5	c(180,70)
P8	107.5	122.5	
P9	107.5	110	
P10	80	82.5	c(80,110)
P11	40	82.5	
P12	-12.5	30	c(40,30)
P1	-12.5	-12.5	

Figure 3: A sample G-code table to be included in the lab report

N1 % Example 1
N2
N3 G70 G90 G17 G40
N4 G0 X-1.0 Y0.0 T1 M06
N5 S1000
N6 G0 X0.0 Y-0.0929
N7 Z0.25
N8 Z0.15 F5.0
N9 G1 X0.0 Y0.0 Z0.5 F20.0
N10 X0.0 Y0.0 Z0.5
N11 X0.0 Y0.0 Z0.0
.
.
N36 X1.0 Y1.25 Z-0.4
N37 X2.0 Y1.25 Z-0.4
N38 G91
N39 G2 X0.0 Y0.0 I0.75 J0.0
N39 M5

N1 %Example 2
N2
N3 G75 G90
N4 G0 X-1.0 Y0.0 T1 M06
N5 S1000
N6 G0 X0.0 Y-0.0929
N7 Z0.25
N8 Z0.15 F5.0
N9 G1 X0.0 Y0.0 Z0.5 F20.0
N10 X0.0 Y0.0 Z-0.1
N11 X1.0 Y1.25
N12 X2.0 Y1.25
N13 G1 Z-0.1 F10
N14 G2 X3.5 Y1.25 R0.75
N15 G2 X2.0 Y1.25 R0.75
N16 G0 Z3.0
N17 X-2.0 Y0.0 M2

Figure 4: Sample part program for the Bridgeport NC

Laboratory Behavior and Safety Guidelines

1. **Absolutely no fooling around in lab.** Equipment in the MIME Shop is dangerous, and therefore, any horseplay will result in dismissal from lab at the instructor's or TA's discretion. Any student dismissed will not be able to make up the lab.
2. **Dress code for MIME Shop (and as directed in the MEEL) is as follows:**
   - EYE PROTECTION – State / OSHA approved safety glasses or goggles must be worn in all areas of the MIME shop and as directed in the MEEL.
   - HEARING PROTECTION – Hearing protection will be provided upon request.
   - CLOTHING – Long pants, short sleeve shirts and socks are required in the MIME Shop and as directed in the MEEL. Shorts, dresses, dangling or loose clothing will not be tolerated. Neckties must be removed. Long sleeves may be rolled to the elbow. Old clothing is preferred as it may get dirty and greasy.
   - JEWELRY – All jewelry must be removed while in the laboratory.
   - FOOTWEAR – No open-toed shoes are allowed (e.g. flip-flops and sandals). Athletic shoes are recommended.
   - HAIR – Long hair must be tied back so that it will not fall into a machine or your work area. A hat of some type is recommended.
   - GENERAL – Never attempt to use equipment without proper instruction and a full understanding of its operation. Never work in the laboratory alone.

NOTE: The Teaching Assistant or instructor will determine if the student has the proper attire to safely work in the laboratory. If a student is not properly dressed, he/she will be asked to leave the laboratory and will not be allowed to complete the lab assignment.

3. **Be careful with lab equipment.** It can be very dangerous if improperly used and is expensive.
4. Be polite and respectful to others.
5. Cleanup starts 10 minutes before lab ends. Please return the work area to pre-lab conditions.
6. Any cuts must be looked at by the Student Health Center before leaving.
7. Do not adjust or alter a machine or other laboratory set-up without permission.
8. **Please retain a copy of these policies for your records.**

Safety Policy Signature

I have read and understood the **MFGE 437: Computer Control of Manufacturing Processes** Laboratory behavior and safety guidelines and agree to comply with these policies.

Signature _____ Date _____

Print name _____