PROJECT 1
MANUAL NC CODE GENERATION

Objective

Machine the component (keychain) shown in Figure 1 below. All dimensions of the part have to be according to the 3D SolidWorks model of the part stored in the *Project 1 – Keychain.SLDPRT* or *Project 1 – Keychain.STEP* file (for those who did not upgrade to the latest version of SolidWorks) provided in OWL along with the current description of the project.

a) b)

Figure 1: a) top view; b) back view.

Additional directions

- Use the area **under** the WE logo on the back view to engrave your team number and the current year (2024).
- While you have the freedom to decide the size and positioning of this engraving, please ensure that your team number and the year are centered relative to the width of the keychain and it is legible when the part is oriented as in Figure 1b.
- If required, you are allowed to reduce the height of the WE logo in order to fit better the team number and the year.
- While "rounded" geometries for digits are not mandatory, they will certainly receive few bonus marks with respect to their "LED/LCD Digital Font" (squared) counterparts.

Deliverables

Please submit the following by **Monday, February 12, 2024 at 4:00 p.m.**:

- *Machined component.*
  The part will be submitted to the TA supervising the activity of your team.
- *Lab report.*

The report will be submitted electronically via OWL (one submission per team). The report should be at least three pages long (single-spaced pages, 12 pts Times New Roman font) and it should include details and/or comments on:

- Machining sequence/technology chosen
- NC programming approach
- Tooling selected and its setup procedure
- Dimensional accuracy and surface quality of the machined part
- "Lessons learned" and ways to improve the overall setup used for this project

- *Two NC code files (*.nc)*
  The NC codes used to machine the keychain will be sent electronically as a *file attachment* via *Assignments* menu in OWL (one submission per team). Machining of this part will require two separate files, one for each workpiece setup (*e.g.* one for side A, one for side B of the workpiece). Please submit the three files (report and NC codes) as a **.zip* or **.rar* archive. Please do not use the inline (*e.g.* copy and paste) option in OWL to submit your NC codes.

Available hardware

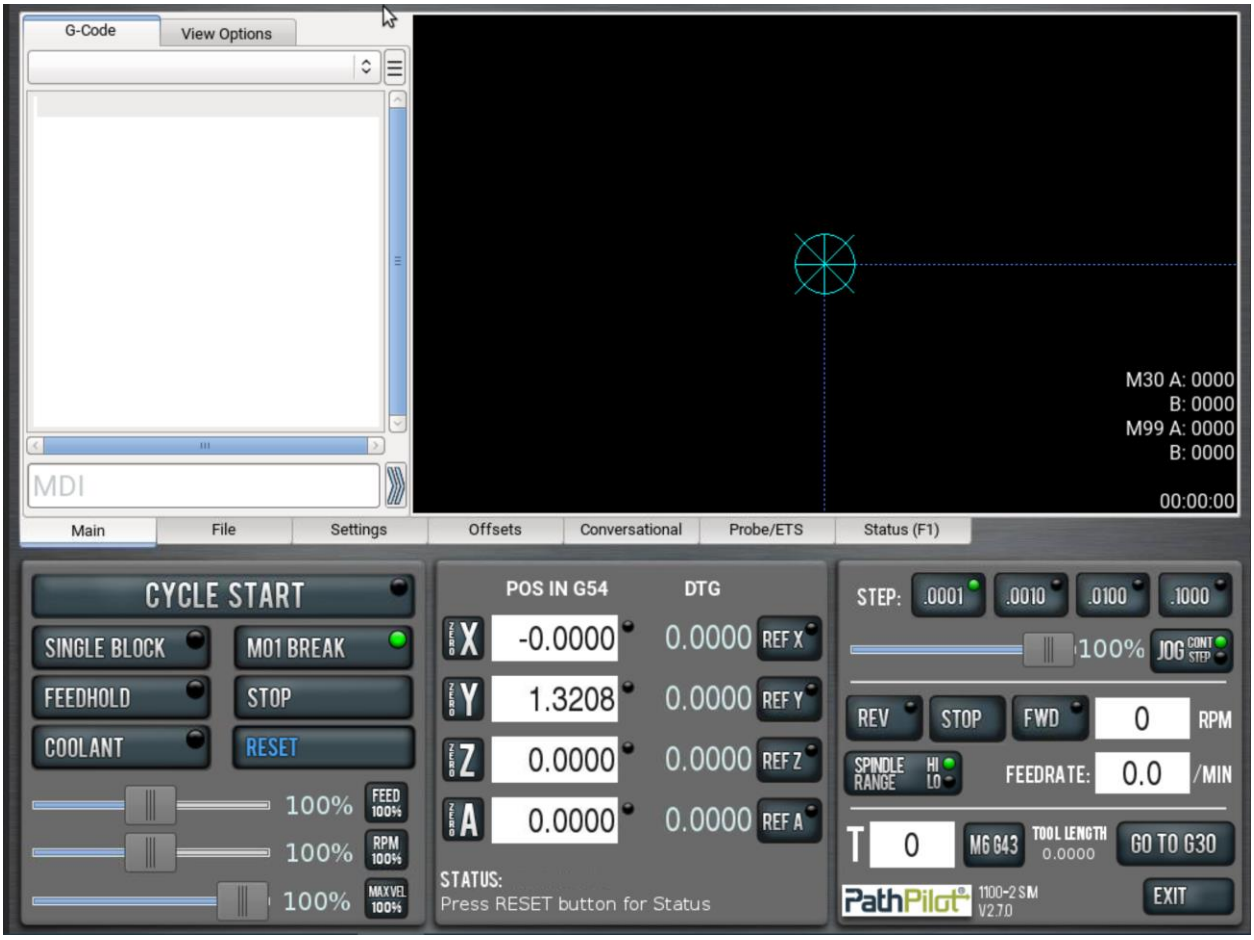
- *Three-axis CNC machine tool:* Tormach PCNC Series II milling machine
- *Fixturing hardware:* Tormach vise, acrylic base plates (cut at 4½" x 4½ " x ¾" approximately), double-sided tape
- *Blanks*: Plexiglas raw stock cut at 2¼" x 1¼ " x 0.23" (approximate dimensions)
- *Cutting tools:*
  - 1/2", 3/8", 1/4", 1/8", and 1/16" flat-end mills
  - 1/4", 1/8" ball-end mills
  - 1/8" drill bit

Available software/digital data

- *Windows-based CNC simulator and backplotting software: PCNC1100M3-II.* The software is installed on the two SEB 1028 lab computers. The kit is available for installation on personal computers, please check the "Course Overview.pdf" file posted in OWL or approach the course instructor for more details. You can also use one of the many free browser-based "NC code viewers" that are available over the Internet, but keep in mind that depending on the encoding used, the PathPilot controller available on the Tormach machine might or might not accept the non-visible characters hidden in your NC code file. This is why it is highly recommended to also preview the tool path by means of PCNC1100M3-II software or - even better - by means of a virtual PathPilot session (please see below).
- *Linux-based CNC simulator and backplotting software: Pathpilot*. This software is run by the controller running the two Tormach machines in SEB 1028. While the GUI (graphical

user interface) is different between PCNC1100M3-II and Pathpilot, backplotting capabilities are almost identical.

- *Virtual/remote CNC simulator and backplotting software: Pathpilot*. This is a new/very new backplotting option (launched in 2020 or late 2019) that allows the testing of the code by means of a virtual machine whose interface and functionality is similar to that of the controller installed on the physical CNC machine in the lab. You can access the PathPilot hub here: https://hub.pathpilot.com/ When asked about the type of machine on which PathPilot will be used, please select "Previous Machine Models", then "Tormach PCNC Series II (series 1326-1999)" and then the option **without** "series 3 upgrades". If everything was setup correctly, the GUI on the screen will be similar to the one in the picture below (that is in turn similar to the one you will see on the CNC machine tool). Using it should be pretty easy, although it is a Linux-based system, after all…



Marking:

The following elements will be considered while marking your project:

- *Dimensional accuracy of the part.*
  All final dimensions of the machined part should be as close as possible to its CAD model. Differences in blank/stock thickness are to be ignored.
- *Part quality/aesthetics/appearance.*

Avoid scratches, burrs, tool marks, dents, scallops and ridges on all machined surfaces. If they do occur, then make sure to comment on their possible source as well as ways to eliminate them. Machining of new parts would be a good way to validate/test out your machining improvements proposals/ideas, but it is not required (unless you are really *keen* to do it and there is still some lab time left for that; please note that the unsupervised use of the CNC machines in the lab will not be allowed for Project 1). Given the time constraints of the lab sessions, valid "theoretical" insight will prevail over its practical validation via a newly machined part.

- *Programming efficiency/process productivity*
  The NC code should be as short as possible (in terms of total number of blocks), should minimize the cutting length (by avoiding/reducing unnecessary overlaps between cutting tracks/passes) and should minimize the length of ancillary (*e.g.* non-cutting) motions. As you will soon notice, a fine balance exists between a fast machining process and a qualitatively superior one. While in the context of this course, the quality will typically prevail over productivity, machining efficiency considerations should not be disregarded.

- *Correctness and professionalism of the report.*
  Please remember that the report should be prepared in a professional manner both with respect to formatting and technical terminology – or machining jargon, if you wish – used in a sense that layman and colloquial terms should be avoided at all costs. The report should also make a good use of explanatory figures, whenever they seem to be appropriate to clarify the concept explained within text. The most important questions to be answered by the report are "what", "how" and "why", but this should be accomplished without their obstinate and/or *ad litteram* repetition throughout the text of the report.

  The report should also include specific comments/table on the noticed discrepancies between the nominal dimensions (*i.e.* those specified by digital master/CAD data) and the effective ones (*i.e.* the ones measured on the part). In terms of improvement means (*e.g.* "lessons learned"), the report can address means to correct "potential" or "real" issues noticed during machining which might have affected (*e.g.* decreased) the overall productivity of the process (which actually translates into fabrication costs) as well as the accuracy/quality of the machined part.

Project policies:

- *Late penalties for this assignment are **20% off per day.***
  Late submissions will not be collected from the locker *unless the instructor is notified about their existence*. If a late submission is found accidentally in the locker at the next collective assignment/project pickup, it will be simply disregarded and the submission will receive 0 marks.

- *Each team member of the same team will essentially receive the same credit.*
  However, those who are absent and/or late for more than 10 minutes during any of the three lab sessions allocated for this project will be *proportionally penalized*. By contrast, if the entire team decides to not show up to a particular lab session, no team penalty will be applied, but the project will still have to be submitted by the assigned deadline. Once again, no makeup classes can be provided, such that you will have to ensure that you will finish your project within the allotted lab sessions/weeks. In engineering terms, this means that **lab time ≈ machine run time**. Please remember: like in production, when the machine is

down, the resources are wasted, which in turn simply means that you did not plan properly your actions (*e.g.* inappropriate project management). In simple terms, all these mean that it would be highly beneficial if you would complete your programming **outside/before your lab session** and then come to the lab just to perform the machining of the workpiece. Most of the times, inexperienced CNC programmers learn where to correct/how to debug their NC codes only after the part was machined. However, if the first part was cut in the very last minutes of the second/last lab session allotted to this project, then there might be no time left to correct the program and cut again a part that matches the set design specifications.