Computer Integrated Manufacturing II

ME345: Automation and Manufacturing Methods

Boston University College of Engineering
Department of Mechanical Engineering

Fall Semester, 2021

Pre-lab assignments should be completed individually, online using Blackboard Learn.

Complete the pre-lab assignment before the start of your lab section.

Lab reports should be submitted in PDF format to Blackboard Learn. Lab reports are completed either as a whole lab section or with your lab partner, according to the course syllabus.

Submit the lab-report on Blackboard Learn before the start of your next lab section.

Contents

1 Learning Objectives

This lab continues to explore automation in the ADML through the Boston University Manufacturing Execution system (BUMES). The learning goals for this lab are:

- Learn how to add robot programs to a BUMES process using the built-in SFTP tools.
- Learn how to create G-Code that is compatible with BUMES.
- Redesign the Cordganizer demo, accomplishing the same tasks but in a different order.

1.1 Lab Deliverables

- Pre-Lab Questions

1.2 Lab Groups

Complete this lab with your lab partner. The laboratory instructor will help troubleshoot and check your programs.

2 Pre-Lab Reading

Cordganizer Body and Lid codes on Blackboard.

3 Pre-Lab Questions

1. The code for the existing Cordganizer Body and Lid processes are on Blackboard. There are several components of the processes listed as follows:

   - Initialization
   - Move an Empty Pallet to Station 3
   - Move an Empty Pallet to Station 4
   - Manufacture the Lid
   - Manufacture the Body
   - Move the Body to the Pallet
   - Move the Lid to the Pallet
   - Bring the Lid back to Station 1
   - Bring the Body back to Station 1
   - Assemble the Body with a Lid

   Draw a diagram that shows these processes. Try to change them so that the Cordganizer will be manufactured in a more efficient way. Draw a second diagram of the more efficient flow. Create your revised process in a text file and attach it as an answer to this question. The existing Cordganizer process is included as a downloadable file in the lab folder on Blackboard.

4 Lab Background and Description

BUMES attempts to simplify the programming of a fully autonomous manufacturing process by incorporating text editors and programming utilities, like Secure File Transfer Protocol (SFTP), within the programming interface. The goal of these exercises is to learn how to create `urDashboard` and `cncRun` tasks using the utilities in BUMES. At the end, students will redesign the Cordganizer Body process to accomplish same tasks as shown in Lab 06, but in a different order.

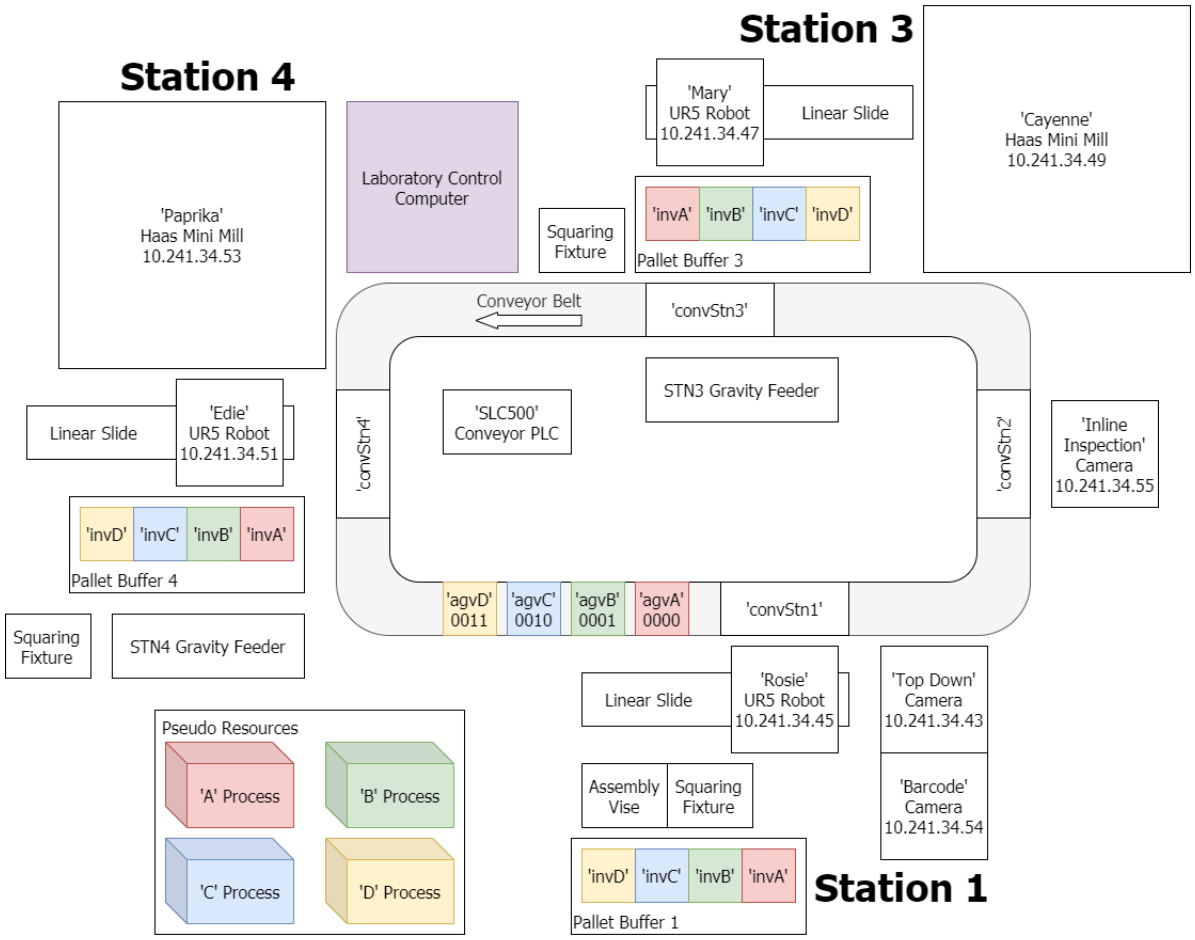

Figure 1: BU FMC Layout Overview

For reference, a graphical overview of the flexible manufacturing cell is included in Figure 1.

5 Lab Method

5.1 Starting up the BUMES and the FMC

5.1.1 Robot Startup

- ☐ Power on all robots.
- ☐ Initialize them with the correct installation file, `admin.installation`.
- ☐ Use the teach pendant to run the program `/programs/me345_admin/_adminRobotHome.urp`. This resets the robot and linear slide.

5.1.2 Milling Machine Startup

- ☐ Power on both milling machines.
- ☐ Press `Reset` to clear any errors and use the `Power Up|Restart` button to initialize the machines.
- ☐ Press `Setting/Graphic` and navigate to the `Network` page on the `I/O` tab. Press `F1` to refresh the network settings.
- ☐ Use `List Program Mode` and the `Select Program` button to load the correct startup file on each machine; `_mesCayenneStartup.txt` and `_mesPaprikaStartup.txt`.
- ☐ Reduce the machine rapids to `25%`.
- ☐ Close the door on the machine and press `Cycle Start`. The code on the machine should illuminate pink and enter an infinite while loop.

5.1.3 Conveyor

- ☐ Locate the conveyor belt power switch located at Station 1, near the additive assembly area.
- ☐ Press the black power button to start the conveyor.

5.1.4 BUMES Startup

- ☐ Click the BUMES shortcut on the desktop to open BUMES (web address: localhost:5000) in Google Chrome.

5.2 Creating a `urDashboard` Task

1. Navigate to the `FMC Overview` page of BUMES using the hyperlinks at the top of the interface.

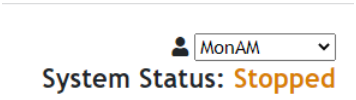

Figure 2: BUMES FMC Overview, Change User

2. Locate the user drop down menu, shown in detail in Figure 2. Select the user corresponding to your lab section. The current user will appear at the top right of the interface.
3. Navigate to the `Process Editor` web page using the hyperlink at the top of the interface.

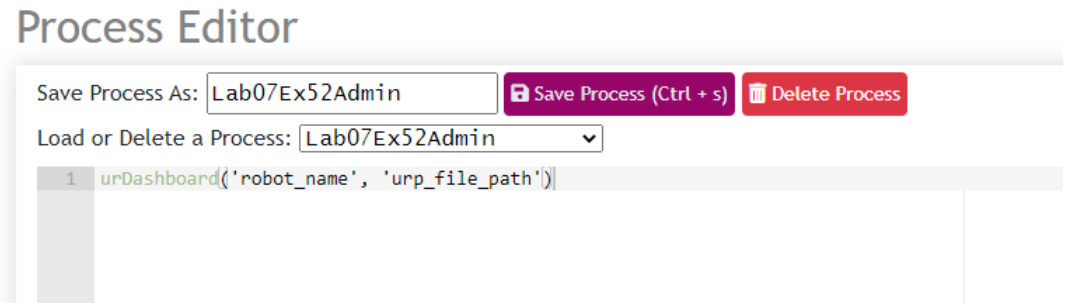

Figure 3: BUMES Process Editor `urDashboard` task

4. In the field called *Save Process As*, enter a filename corresponding to the lab and your lab section, such as `Lab07Ex52ThursAM` (special characters are not allowed in the process name).
5. In the text editor, begin typing `urDashboard`. When entered correctly, the task will illuminate in green. If there are typos, the task will not highlight. Steps 4 and 5 are shown in more detail in Figure 3.
6. Press `Save Process` or use `Crtl + S` to save the process. The webpage will refresh, indicating the that save was successful.

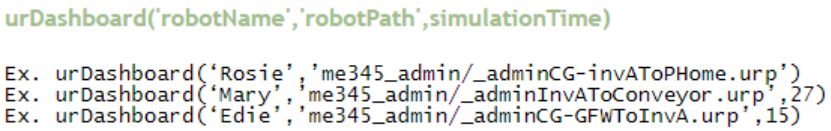

Figure 4: BUMES Process Editor *README* excerpt

7. In the *README* on the right side of the screen, scroll down until you find the documentation for the `urDashboard` task. Notice there are three arguments and some examples are given. This is also shown in Figure 4.

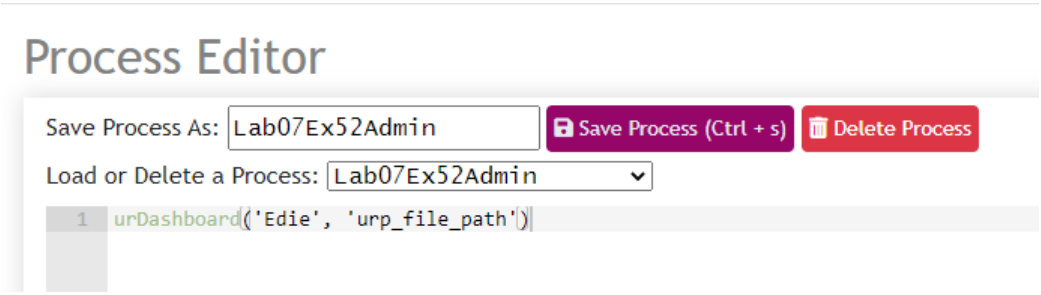

Figure 5: BUMES FMC Overview, Operations Menu

8. Imagine you are the BUMES operator trying to create a simple program that uses UR5 Edie to move an empty pallet from the conveyor belt to an inventory slot. The first argument to the `urDashboard` task would be `'Edie'`. Be sure to use single-quotes to indicate to BUMES that a string is being passed. Enter `'Edie'` into the task and be sure to save the process, as in Figure 5.

9. Now, to find the complete list of program in Edie's controller, first navigate to the `Robot Wizard` using the hyperlink at the top of the interface.

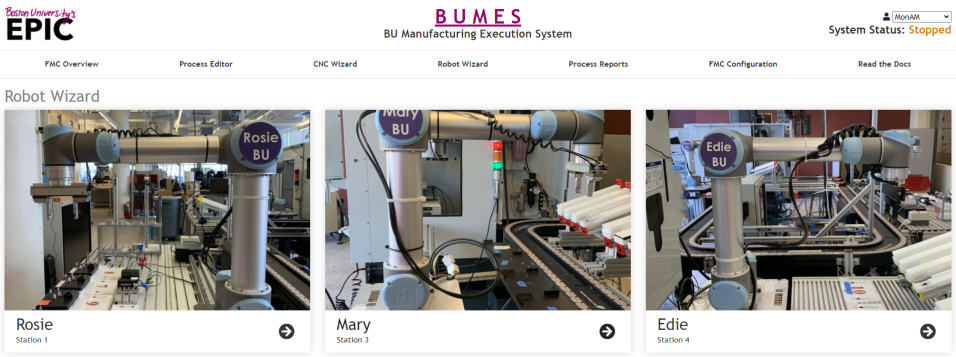

Figure 6: `Robot Wizard` robot selection menu

10. Select `Edie`.

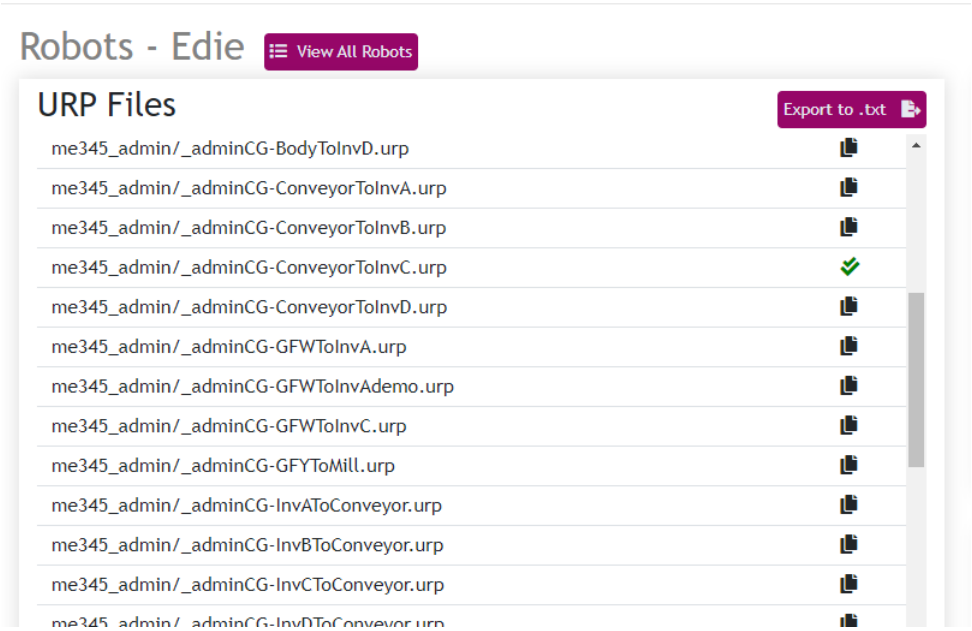

Figure 7: `Robot Wizard` displaying files on Edie's controller

11. In the list, find the URP filename for the program that moves a pallet from the conveyor to inventory C. In this case, the file was prepared by the ME345 administrator for the Cordganizer demo. Find that filename and check with the laboratory instructor to ensure the correct file is selected.

12. Copy the filename from the list by clicking the copy button to the right of the name, and return to the `Process Editor` web page.

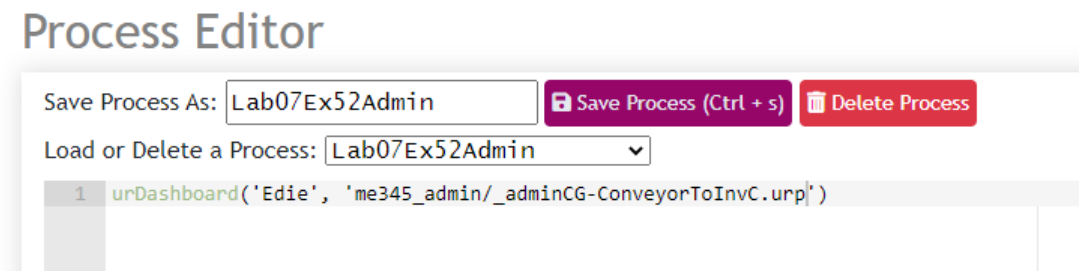

Figure 8: `Process Editor` with a completed `urDashboard` task

13. Recall step 7 of this exercise. The *README* states the second argument to the `urDashboard` task is a `'robotPath'`. In this case, the `'robotPath'` is the filename copied in the previous step. Paste it inside the single quotes in the task. Be sure the arguments are separated with commas. A complete example is shown in Figure 8.

14. Optionally a third `'simulationTime'` argument can be passed to the task. This corresponds to the time, in seconds, that the task should take in `Full-Simulation` mode.

The `urDashboard` command `loads` and `plays` URP files.

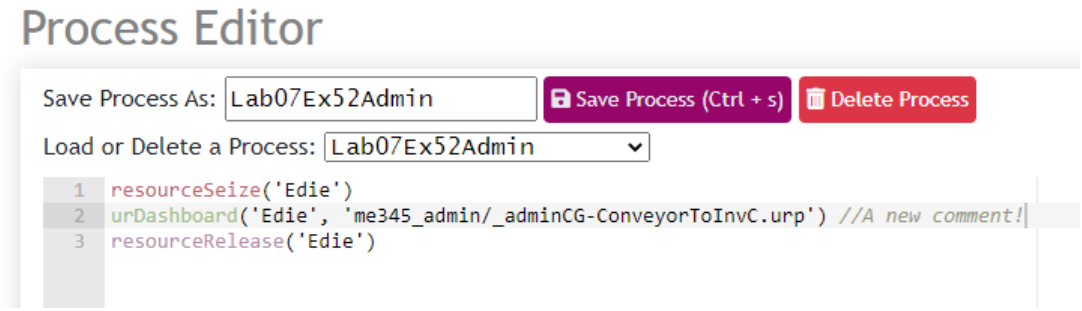

Figure 9: `Process Editor` with a completed `urDashboard` task

15. Make this simple program more robust and easier to read, as shown in Figure 9:
    - Add a `resourceSeize` task to indicate that the process requires exclusive access to Edie.
    - Use `//` to add a comment to your program, indicating what task 2 does (comments must be on the same line as a task).
    - Add a `resourceRelease` task to indicate that the process no longer need exclusive access to Edie.

16. Save the program! Unsaved changes will be lost if operator navigates to a different web page without saving. Optionally, the `Export to Text File` button, shown in the CIM I Lab, can be used to create backups of process files.

17. Navigate to the `FMC Overview` web page.

18. Ask the laboratory instructor to ensure Edie is on and ready.

19. Click `Post Operations`, add `2` units of your new lab process, post, and execute the program in `Real-Run` mode.

5.3 Creating a `cncRun` Task

BUMES is able to access and manipualte a shared folder hosted on the laboratory control computer. The CNC machines are configured to read and execute G-Code from this shared directory. BUMES has a utility for creating compatible G-Code.

1. Navigate to the `FMC Configuration` web page using the hyperlinks at the top of the BUMES interface.

Figure 10: `FMC Configuration` web page

2. The FMC configuration is a text file in JSON format that contains all of the resources in the FMC as well as unique identifiers, types, locations, and other information relevant to BUMES.

If you are ever confused about which resources are available in the system, like the name of a specific CNC machine, robot, conveyor station, or camera, refer to the FMC configuration. The name of the resource, as it appears in this document, is how the resources is called in tasks within the `Process Editor`. Only the ME345 administrator should make changes to this file, as it can effect the behavior of the system or other operators' process files.

JavaScript Object Notation (JSON, pronounced 'Jason') appears throughout BUMES as a convenient, human-readable data structure for stashing information from operating files, process reports, and configuration files. Learn more about JSON here: `https://www.json.org/json-en.html`.

3. For practice, find the two resources with `"type":"CNC"` and take note of their names. These are the names that can entered into the `cncRun` command.

4. Navigate back to the `Process Editor` web page.

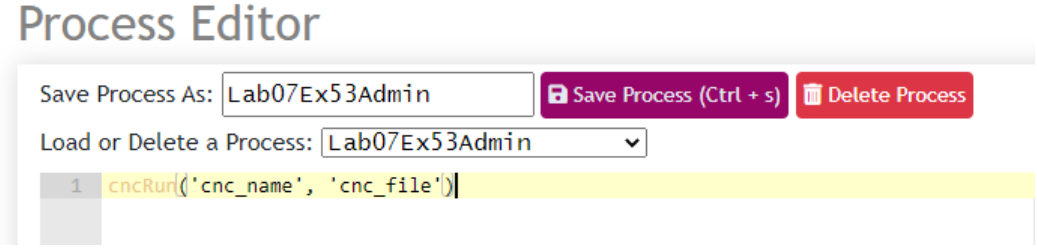

Figure 11: `Process Editor` with a `cncRun` task

5. Enter a new name for a process, such as Lab07Ex53WedAM. Clear the text editor if there are any commands, then save the new process

6. As in Figure 11, begin entering a `cncRun` task. The first argument, according to the *README* is the `'cncName'`; enter `'Cayenne'` for this exercise.

7. Save the process and navigate to the `CNC Wizard` web page.

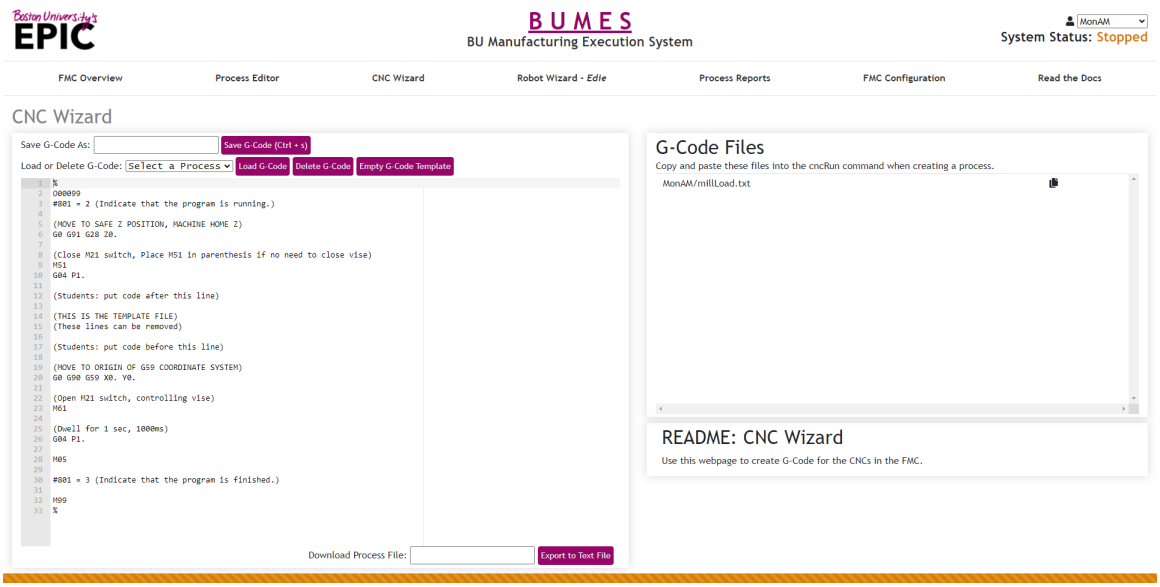

Figure 12: `CNC Wizard` web page

8. The `CNC Wizard` web page appears as it does in Figure 12. There are three main sections:

   - The G-Code text editor on the left side of the interface.
   - A complete list of available G-Code files on the upper-right side of the interface.
   - A *README* section on the lower-right side of the interface.

   Notice, there should be at least one file already located in the folder, `millLoad.txt`. Each BUMES user stores G-Code files separately to avoid confusion.

9. G-Code created for the FMC will typically be created in GibbsCAM. After post-processing, the G-Code generated by GibbsCAM must be modified slightly, then added to the BUMES template. Navigate to Blackboard and download `Lab07_ZIP` (`Blackboard >> Content >> Lab Material >> Lab 07`).

10. Extract the contents of the ZIP folder and Launch GibbsCAM on the laboratory control computer.

11. Open the file `Lid.envc` in GibbsCAM. This is the file used to create a Cordganizer Lid.

12. The ZIP file also includes the Haas post processor file. Use GibbsCAM to post the file. Save the file somewhere convenient like the Downloads folder or Desktop.

13. Find the `NCF` file from the previous step and open it in a text editor, like Notepad.

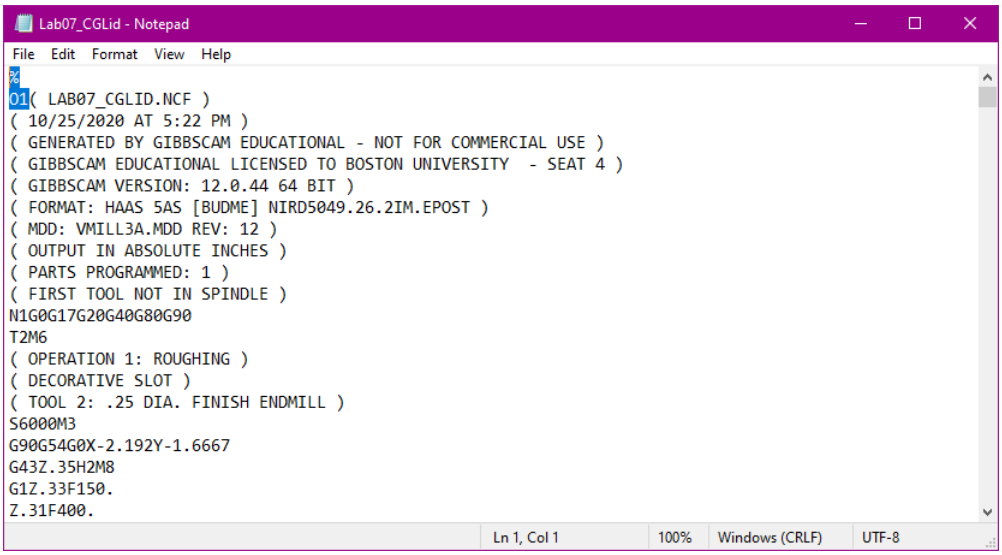

Figure 13: G-Code lines to remove, first figure

14. To make this G-Code compatible with BUMES, begin by deleting the `%` symbol and operation number, `O1` from the beginning of the file, highlighted in Figure 13.

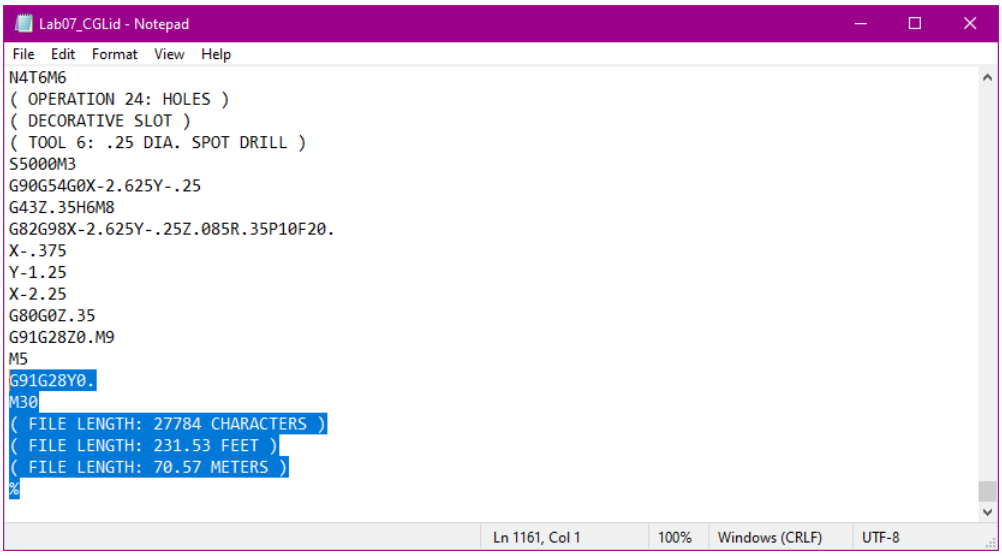

Figure 14: G-Code lines to remove, second figure

15. Scroll to the end of the file and find the lines highlighted in Figure 14. Remove these lines of G-Code as well. Save the changes to the file.

16. Close GibbsCAM and return to the BUMES `CNC Wizard`.

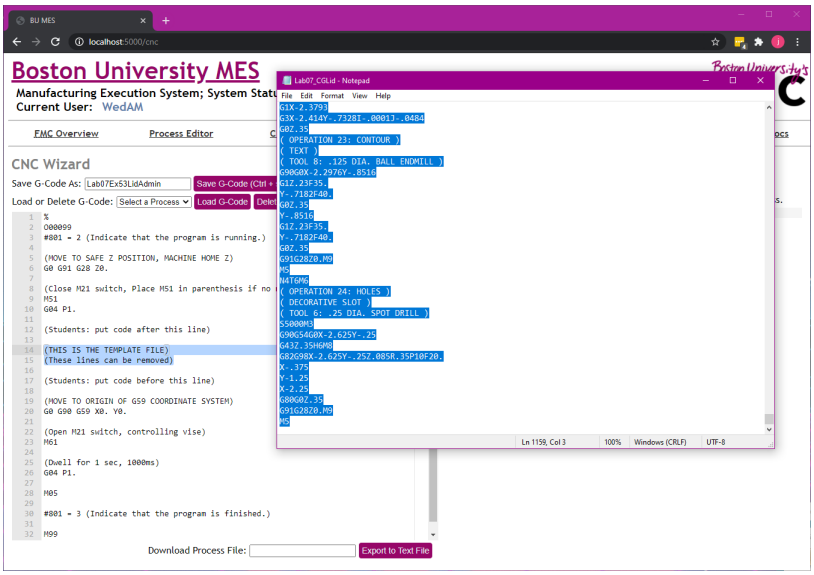

Figure 15: Creating a new BUMES G-Code file

17. Enter a filename for this new G-Code file, such as Lab07Ex53LidMonAM.

18. Refer to Figure 15. Copy the contents of the modified G-Code file into an empty BUMES template, replacing the lines that say:

```
(THIS IS THE TEMPLATE FILE)
(These lines can be removed)
```

19. Save the file by clicking the `Save G-Code` button or by using `Ctrl + s`.

20. Once the file is saved, it should appear in the list of G-Code files in the upper-right side of the interface. Like the `Robot Wizard`, copy the new filename.

21. Navigate to the `Process Editor` web page.

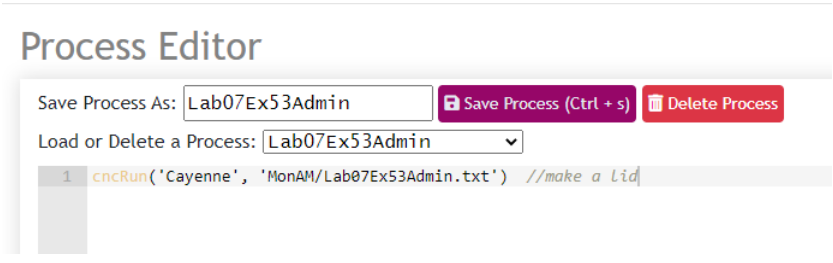

Figure 16: G-Code lines to remove, second figure

22. Finish the process started earlier by adding a `'cncFile'` argument, the filename copied from the CNC wizard, also shown in Figure 16.

23. Save the process and ask the laboratory instructor to check the program.

24. If the instructor approves, they will start Cayenne,load a piece of stock material, and clamp it in the vise.

25. Navigate to the `FMC Overview` web page.

26. Post 1 unit of the new lid process to the system, then execute the operation in `Real-Run` mode.

5.4 Redesign the Cordganizer Body Process

BUMES offers the flexibility to start processes anywhere in the system, as long as the original location of the pallet is noted by the operator. Using the file(s) created in the pre-lab assignment, the Cordganizer body workflow will be changed to accomplish the same general workflow in a different order.

1. Using the file(s) created during the pre-lab assignment, create new processes in BUMES necessary to manufacturer 2 completed Cordganizers. Work with lab mates to troubleshoot and debug them. If necessary, ask the laboratory instructor for assistance.
2. Once complete, ask the laboratory instructor to check the new program.
3. Export the finalized text files.
4. On the FMC Overview, post your new processes to make 2 completed Cordganizers. Run this in `Quick-Simulation` mode to check for errors.
5. After a final approval from the laboratory instructor, post your processes in the order that you determined would be optimize the system to make 2 Cordganizers, and run the system in `Real-Run` mode and observe the behavior.
6. Download the Process Reports, which are needed to complete the lab report.

5.5 Data Processing

1. Navigate to `https://trinket.io/embed/python3`.
2. Use your results to change out the relevant portions of the Python code file called Plot Timeline, which can be found on Blackboard.
3. Paste your code into the main.py tab.
4. Press Run.
5. Right-click on the resulting image and save it for your lab report.

6 Lab Report

Complete the lab report with your lab partner. Submit a PDF to Blackboard before Dec. 13 midnight.

6.1 Questions

1. Analyze your data generated in Lab 5.4, report the times corresponding to the key times listed in the pre-lab questions and plot a timeline. (You can use the code in 5.5 or write your own code to plot it)
2. Review your data generated in CIM 1 Lab 5.3, report the times corresponding to the key times listed in the pre-lab questions and plot a timeline as well.
3. Compare the two times. Have you succeeded in improving the process to become more efficient? How much time have you saved? If not, what may be the problem?