Lorain County Community College

PROJECT BASED LEARNING (PBL) FOR PROGRAMMABLE LOGIC CONTROLLERS

Lorain County Community College

Learning Objectives

- Develop a program that is efficient, uses as few lines as possible, and the program flow is easily followed.
- Apply the programming techniques and utilize the various instructions from the Rockwell training.
- Program the PLC to sort different products traveling on a conveyor.

Safety

- Conduct a thorough risk assessment before the activity to identify potential hazards. Assess the equipment, environment, and the specific tasks involved in programming the robot and PLC.
- Properly document all PLC programs to facilitate troubleshooting and maintenance.
- Wear appropriate Personal Protective Equipment (PPE), such as safety glasses and closed-toe shoes.
- Organize the workspace to minimize clutter and ensure clear pathways for both robots and students. Keep the area well-lit to enhance visibility.
- Understand emergency procedures, including the location of emergency exits, first aid kits, and the proper use of emergency equipment like fire extinguishers.
- Ensure a qualified instructor or supervisor is present during the entire lab activity to provide guidance, answer questions, and intervene in case of emergencies.
- Ensure appropriate behavior during the lab activity, including the prohibition of horseplay or any actions that may compromise safety.

Equipment/Materials

- Rockwell PLC Trainer
- Conveyor Trainer
- Computer with Studio 5000
- Parts
- Metal and non-metal parts
- Metal parts with hole and no hole
- Non-metal parts with hole and no hole
- Sorting Metal vs Non-Metal parts, using inductive sensor,
- Next level, sort metal vs not metal, with hole and no holes. Use photo electric and inductive.

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Problem Statement

Utilizing the Rockwell PLC trainer and conveyor trainer, create a program that sorts the metal and non metal parts into the different bins. Ensure the system picks the base of the metal tin from the conveyor when the part is present. After picking the base of the metal tin, place the metal tin in the assembly fixture, and activate the clamp once the robot has released the part. After picking the base of the metal tin, pick the metal tin lid from the parts feeder, after verifying the part is present. Then place the lid on top of the base and press the lid into place. This will push the two pieces together to compete the assembly of the metal tin. After completing the assembly, repick the part and place in it the drop off location.

Procedure

Utilizing the Rockwell PLC trainer and conveyor trainer, create a program that sorts the metal

Step 1: Initialize any Registers, Frame settings, move to wait/home position, reset tooling...etc. before starting
Step 2: Add commands to energize conveyor until a part is present (Robot should wait if there is no part present).
Step 2: Program the Robot to pick part A off conveyor once part A is present
Step 3: Move part A into the assembly fixture, after the part is dropped off the assembly fixture should clamp the part into place.
Step 4: Program robot to pick part B off the parts feeder, robot should check to see if part is present before picking.
Step 5: verify part A is in the assembly fixture, the robot should then assemble part A and part B by setting part B on top of Part A and activating the press cylinder.
Step 6: Unclamp the finished assembly and have the robot pick the finish product
Step 7: Move to the wait position
Step 8: Drop part into the finish product box.
Step 9: Return to home and repeat the process.

It is assumed that the robot will go to a pounce position between each process. The program should repeat itself if the robot has stock to make a finished product. Utilize subprograms to make the program more efficient, this will also be necessary for future projects. Utilize stack light to indicate system is running and status of build.

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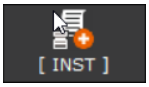
Initial Setup:

After turning on the Cert Cart and letting the Teach Pendant load, Press the **Select Key**. Press the F2 key to **CREATE** a new program. Enter in the Program name: **MAINPRG_PROJECT1A.** After entering in the program name press the **ENTER** key twice to start editing the program.

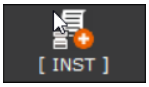


Step 1:

Enter in the UFRAME and UTOOL numbers that the robot will utilize for this lab:

Use User Frame 1 and User Tool 1

```
  1:  UFRAME_NUM=1
  2:  UTOOL_NUM=1
```



(Use Procedure 11-3 on page 172 of FANUC HandlingTool and Programing Manual for reference)

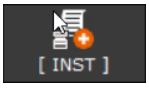
Step 2:

Add the Position Register (PR) offset data for PR 5, 6 and 7.

1. Press the F! key for INST, if INST is not visible press the next key on the Teach Pendant.
2. Select Registers (1)
3. Select option 1 ….=….
4. Select option 3 PR[i,j]
5. Enter in 5 for i and 3 for j. (5 represents position register 5 (PR[5]) while the 3 represents the position register element number (3 is equal to Z). See chapter 17 (PR Offsets) for more information.
6. Next select option 2 (constant) and enter in 100

Repeat the above steps for PR[6] and PR[7] using the same element number and constant value.

```
3:  PR[5,3:OFFSET_CONVY]=100
4:  PR[6,3:OFFSET_CLAMP]=100
5:  PR[7,3:OFFSET_LID_PICK]=100
```

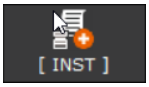


Step 3:

Add the I/O instructions below, this will open the robot gripper. (Also helps ensure the gripper is in the right state to complete the first task)

1. Press the F1 Key for INST.
2. Select option 2 (I/O)
3. Select option 3 (RO[ ]=…)
4. Enter in 3 (this could change depending on which Robot Output controls the gripper)
5. Select option 1 (On)

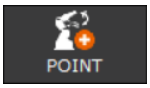
```
6:  RO[3]=ON
```



Step 4:

Enter in the payload instruction below. Use procedure 8-3 pg.95 in FANUC HandlingTool Manual for reference.

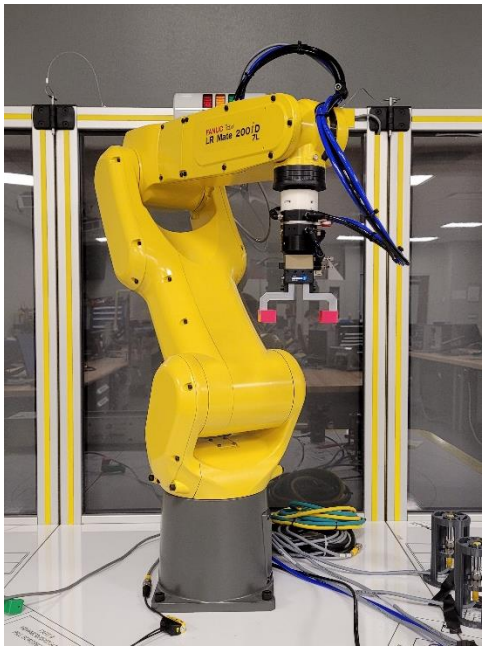
```
   7: PAYLOAD[1]
```



Step 5:

Jog the robot to the Home position

Enter in the motion instruction below for the Home position, use PR 1 (this position has to be recorded as home)



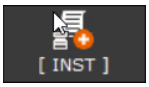
Note: The position register instruction must be recorded under Data.

See procedure 12-3 and 12-4 on pgs. 195 and 196 in the FANUC HandlingTool Manual

To enter in the instruction, see procedure 12-7 on pg. 197 of FANUC HandlingTool Manual

To change the speed and termination type refer to procedure 12-9 and for changing termination type refer to 12-10 but highlight the termination type instead of the speed, and choose CNT for continuous.

```
8:J @PR[1:HOME] 5% CNT50
```



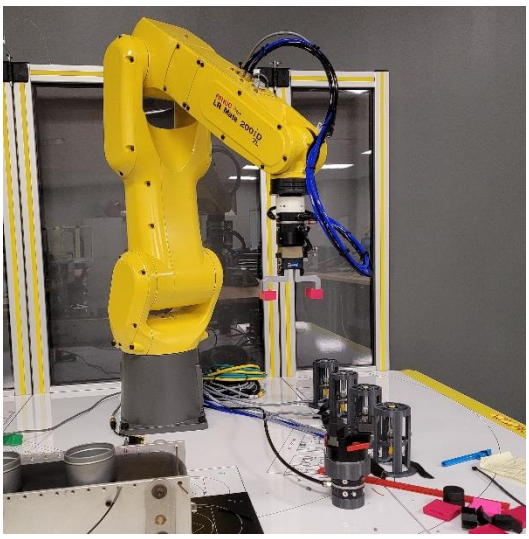
Step 6:

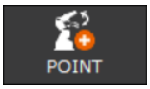
Add a Label instruction.

1. Press F1 key for INST.
2. Select option 5 JMP/LBL
3. Select option 2 LBL
4. Enter in a 1

```
   9: LBL[1]
```

Step 7:

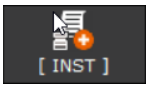




Following the procedures from Step 5, add the following motion instruction. This position will need to be recorded.

Note: the pounce position is in a general location that is close to the areas of work (Ex. Conveyor Pick location, Clamp Location…etc.). This position is making the robot ready to jump to a certain location/ area of work.

```
10:J @PR[2:POUNCE] 5% CNT50
```



Step 8:

Add the CALL instruction below, select the program called CONVEYOR from the list

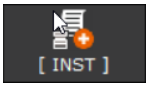
1. Press the F1 Key
2. Select option 6 CALL
3. Select option 1 Program
4. Select the Program called CONVEYOR from the list and press the Enter Key

```
11:  CALL CONVEYOR
```

Note: The program Conveyor has been created for you, but the program is blank currently, we will add the instructions to the program at a later step

Repeat the steps above for the Program calls listed below:

```
12:  CALL PLACE_PART_A
13:  CALL PICK_PART_B
14:  CALL ASSEMBLY_PRG
15:  CALL DROP PART
```



Step 9:

Add a Jump Label instruction.

1. Press F1 key for INST.
2. Select option 5 JMP/LBL
3. Select option 1 JMP LBL [ ]
4. Enter in a 1

```
16:  JMP LBL[1]
```

The Main program is now complete, we will now program the subroutines.

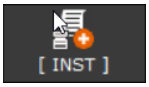
Step 10:

Locate the program called **CONVEYOR:**

1. Press the SELECT key
2. Use the arrows to scroll down or up to locate the program

   Hint: holding the SHIFT key while pressing the up or down arrows will allow you to jump by page.

3. After locating the program and highlight it, press the ENTER key to open the program for editing.



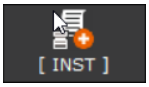
Step 11:

Enter in the UFRAME and UTOOL numbers that the robot will utilize for this lab:

Use User Frame 1 and User Tool 1

```
  1:  UFRAME_NUM=1
  2:  UTOOL_NUM=1
```

(Use Procedure 11-3 on page 172 of FANUC HandlingTool and Programing Manual for reference)

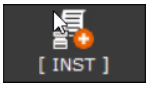


Step 12:

Add the I/O instructions below, this will energize the conveyor.

1. Press the F1 Key for INST.
2. Select option 2 (I/O)
3. Select option 1 (DO[ ]=…)
4. Enter in 121
5. Select option 1 (On)

```
3:  DO[121]=ON
```



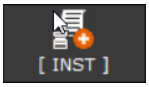
Step 13:

Enter in the WAIT instruction below. This instruction will tell the robot to wait for DI 121, which will tell us if a part is present on the conveyor.

1. Press the F1 Key for INST.
2. Select option 4 WAIT
3. Select option 2 WAIT…=…
4. Select option 3 DI[ ]
5. Enter in 121
6. Select option 2 On

Wait for DI121=OFF sensor is NC

```
4:  WAIT DI[121]=ON
```

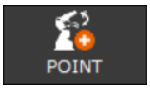


Step 14:

Add the I/O instructions below, this will de-energize the conveyor.

1. Press the F1 Key for INST.
2. Select option 2 (I/O)
3. Select option 1 (DO[ ]=…)
4. Enter in 121
5. Select option 2 (Off)

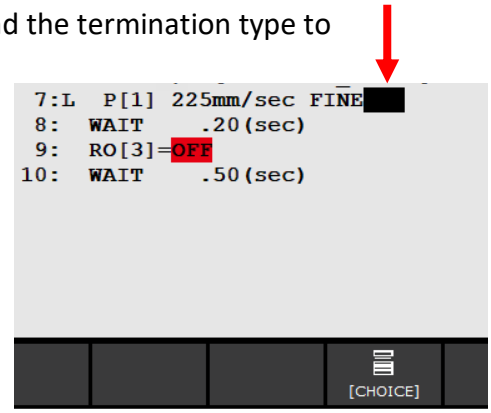
```
5:   DO[121]=OFF
```



Step 15:

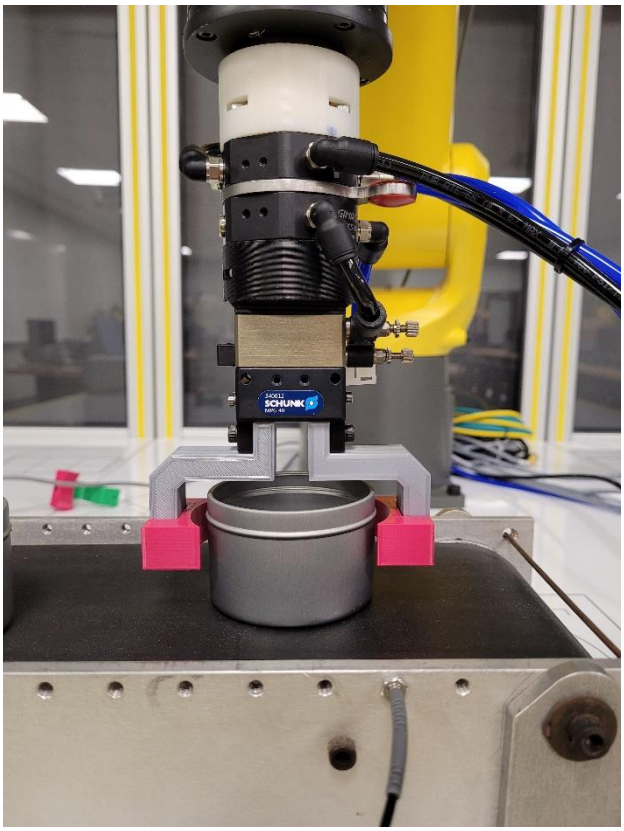
Add the motion instruction below, with the Motion Option: Offset, PR[ ]

1. Record JP[1] at the **pickup location** on the Conveyor
2. After recording JP[1] make sure to set the speed to 5% and the termination type to FINE.
3. Next Arrow over to the end of the motion instruction as seen in the image on the right. (your cursor/pointer should be to the right of the termination type)
4. Press the F4 key for Choice
5. Select Next page
6. Select Option 1 Offset, PR[ ]
7. Enter in 5



This instruction will know cause JP[1] to be offset 100mm in the z direction. This will tell the robot to move 100mm above the pickup location on the conveyor. This will allow you to teach one position for the pick-up and above/clearance position.

```
6:J  P[1] 5% FINE
 :   Offset,PR[5:OFFSET_CONVY]
```



POINT

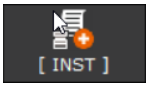
Step 16:

Add the motion instruction below:

1. Press the SHIFT key and F1 (for point) to record a temporary motion instruction
2. Renumber the position as 1. (in the previous instruction the robot performed an offset of this position (the pick-up position you recorded to P[1]).
3. Highlight the J, press the F4 key for choice
4. Select option 2 for Linear
5. Change speed to 225mm/sec.
6. Make sure termination type is set to FINE

```
7:L  P[1] 225mm/sec FINE
```

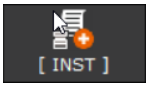
This instruction needs to be linear, because this will move the robot in position to pick the part, at a strait angle/ direction.



Step 17:

Add the wait instruction below:

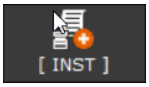
```
8:  WAIT     .20(sec)
```



Step 18:

Add the I/O instruction below, this will cause the gripper to close, which will in return clamp onto the part.

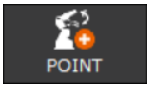
```
9:  RO[3]=OFF
```



Step 19:

Add the wait instruction below:

```
10:  WAIT     .50(sec)
```

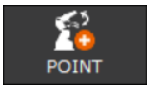


Step 20:

Repeat step 15 or copy the instruction and paste it on line 11 of the program

```
11:L  P[1] 225mm/sec FINE
  :  Offset,PR[5:OFFSET CONVY]
```

See procedure 13-3 for Copy and Paste (pg.216), use POSID when pasting



Step 21:

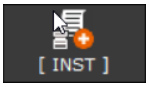
Add the motion instruction below. Refer to step 5 and 7 for reference.

Note: you recorded this position in step 7

```
12:J @PR[2:POUNCE] 100% FINE
```

The Conveyor program is now complete, we will now program the next subroutine.

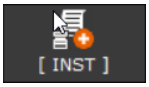
Next Page:



Step 22:

Locate the program called **PLACE_PART_A**

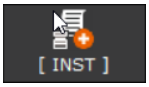
Refer to **Step 10** for the procedure on locating a program.



Step 23:

Enter in the following instructions:

```
  1:  UFRAME_NUM=1
  2:  UTOOL_NUM=1
```



Step 24:

Enter in the I/O instruction below:

This helps ensure that the Clamp is de-energized, so we can place the part in the clamp fixture.

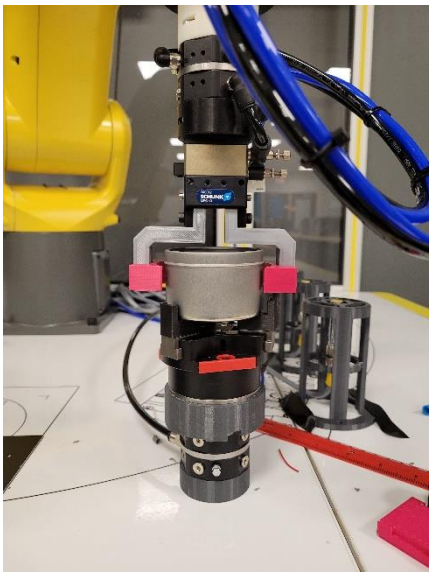
```
  3:  DO[122]=OFF
```

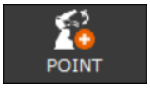
Step 25:

Enter in the motion instruction below, refer to Step 15 for the procedure on entering in an motion instruction with an motion option: Offset,PR[ ]

Record the position as the drop off location in the clamp see picture on right for reference. The offset will cause the robot to move 100mm above this position (in the Z direction).

```
  4:J  P[1] 5% FINE
    :  Offset,PR[6:OFFSET_CLAMP]
```

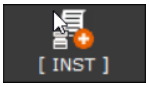




Step 26:

Enter in the motion instruction below, refer to Step 16 to reference the procedure on adding this type of instruction.

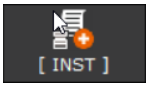
```
5:L  P[1] 225mm/sec FINE
```



Step 27:

Add the I/O instruction below to open the gripper, releasing the part in the clamp fixture.

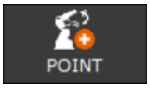
```
6:   RO[3]=ON
```



Step 28:

Add the wait instruction below, this gives the gripper time to open, releasing the part.

```
7:   WAIT     .50(sec)
```

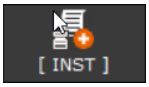


Step 29:

Repeat step 26 or copy the instruction and paste it on line 8 of the program

```
8:L  P[1] 225mm/sec FINE
  :  Offset,PR[6:OFFSET CLAMP]
```

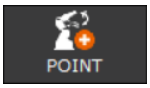
See procedure 13-3 for Copy and Paste (pg.216), use POSID when pasting



Step 30:

Add the I/O instruction below, to energize the clamp. This will hold the base in place and locate it for assembly.

```
9:   DO[122]=ON
```



Step 31:

Add the motion instruction below:

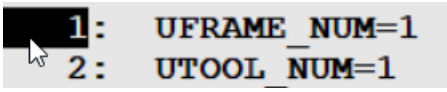
```
10:J @PR[2:POUNCE] 5% CNT50
```

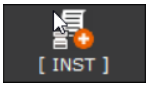
The PLACE_PART_A program is now complete; we will now program the next subroutine.

Next Page:

Step 32:

Locate the program called **PICK_PART_B,** add the following instructions to the first two lines of the program.

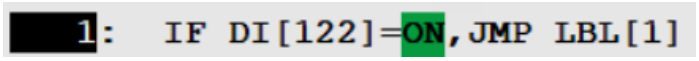




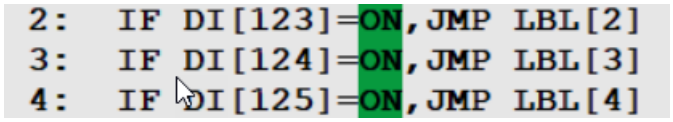
Step 33:

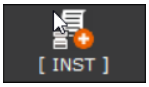
The first 4 lines of this program is logic that determines which part to pick up. There are four pick up locations in the workcell for the lid, and this will determine which one to pick from based on the availability of the part (the lid to the metal container). Each pick up fixture has an inductive sensor, that tells the system if the lid is present or not. If the first station has no part then the program will check the next one and so on. If no parts are present the program will go to the ERROR program. If a parts is present the system will then jump to the correct logic to pick the part (the lid) and move on to the next phase of the program.

1. Press F1 key for INST.
2. Select option 3
3. Select option 1 IF…=…
4. Select option 3 DI[ ]
5. Enter in 122 and press enter
6. Select option 2 On
7. Select option 1 JMP LBL [ ]
8. Enter in 1 and press enter



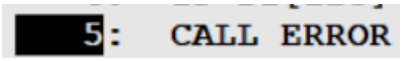
Repeat for the following IF statements using DI 123, 124 and 125 and LBLs, 2,3 and 4





Step 34:

Enter in the Call instruction below, use program called ERROR:



[INST]

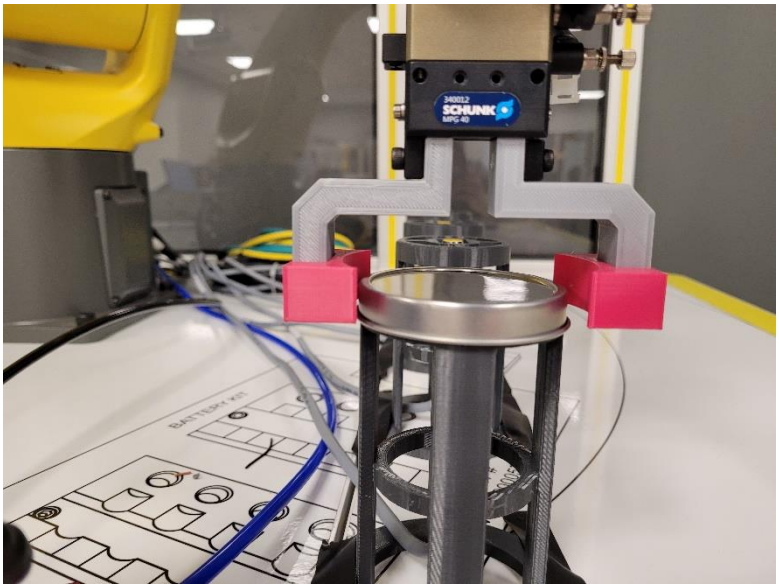
POINT

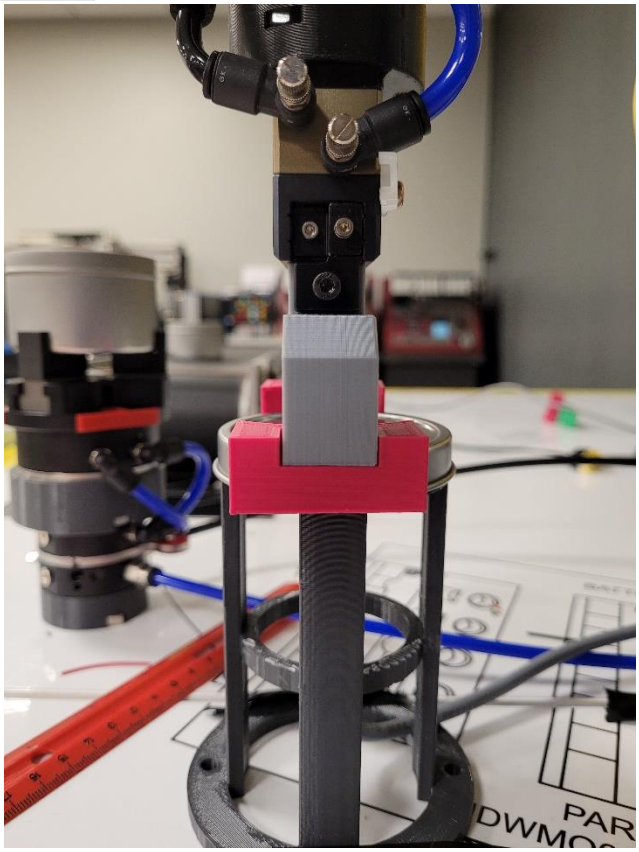
Step 35:

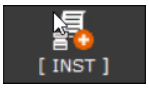
Enter in the following lines of code:

Position 1 (P[1]) should be taught at the pick-up location for the lid parts feeder. See image below.

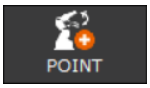
```
 6:   LBL[1]
 7:J   P[1] 5% CNT50
  :   Offset,PR[7:OFFSET_LID_PICK]
 8:L   P[1] 225mm/sec FINE
 9:   RO[3]=OFF
10:   WAIT    .50(sec)
11:L   P[1] 225mm/sec FINE
  :   Offset,PR[7:OFFSET_LID_PICK]
12:   JMP LBL[5]
```







Step 36:



The remaining lines of code have been pre-programmed, but the positions need to be taught. Each group has one position associated with it and that is the pick-up position. We only have to teach the pick-up position, because the offset in that initial motion instruction will tell the robot to offset from that position by 100mm (this was defined in the main program).

Teach at part pick-up location, lid parts feeder location 2

```
  13:   LBL[2]
  14:J  P[2] 5% CNT50
    :   Offset,PR[7:OFFSET_LID_PICK]
  15:L  P[2] 225mm/sec FINE
  16:   RO[3]=OFF
  17:   WAIT     .50(sec)
  18:L  P[2] 225mm/sec FINE
    :   Offset,PR[7:OFFSET_LID_PICK]
  19:   JMP LBL[5]
  20:   LBL[3]
  21:J  P[3] 5% CNT50
    :   Offset,PR[7:OFFSET_LID_PICK]
  22:L  P[3] 225mm/sec FINE
  23:   RO[3]=OFF
  24:   WAIT     .50(sec)
  25:L  P[3] 225mm/sec FINE
    :   Offset,PR[7:OFFSET_LID_PICK]
  26:   JMP LBL[5]
  27:   LBL[4]
  28:J  P[4] 5% CNT50
    :   Offset,PR[7:OFFSET_LID_PICK]
  29:L  P[4] 225mm/sec FINE
  30:   RO[3]=OFF
  31:   WAIT     .50(sec)
  32:L  P[4] 225mm/sec FINE
    :   Offset,PR[7:OFFSET_LID_PICK]
  33:   LBL[5]
  34:J @PR[2:POUNCE] 5% CNT50
  35:   IF DI[122]=ON,JMP LBL[...]
[End]
```

Teach at part pick-up location, lid parts feeder location 3

Teach at part pick-up location, lid parts feeder location 4

[INST]

Step 37:

Locate the program called **ASSEMBLY_PRG** add the following instructions to the first two lines of the program.

```
  1:  UFRAME_NUM=1
  2:  UTOOL_NUM=1
```

Step 38:

For this step jog the robot so the lid is lined up with the base and the lid is pressed onto the base with the ROBOT. Put the robot in a slow speed (5-10%) and use world jog mode to jog the robot into the position where the lid is pressed onto the base (assembled). See images below for reference:

POINT

Enter in the motion instruction below, teaching the location of P[1] at the final assembly location of the lid pressed onto the base of the meatal container.

```
  1:J   P[1] 5% CNT75
    :   Offset,PR[6:OFFSET_CLAMP]
  2:L   P[1] 225mm/sec FINE
```

For the instruction below. Refer to Step 2 for the procedure on defining an offset.

Negative 9 (-9)

```
  3:   PR[8,3]=(-9)
```

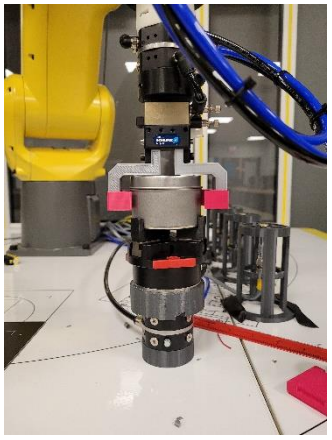
Enter in the remaining instructions below:

```
  4:L   P[1] 100mm/sec FINE
    :   Offset,PR[8]
  5:   RO[3]=ON
  6:   WAIT     .50(sec)
  7:L   P[1] 225mm/sec FINE
    :   Offset,PR[6:OFFSET_CLAMP]
[End]
```

Step 39:

Locate the program called **DROP_PART** add the following instructions to the first two lines of the program.

```
  1:  UFRAME_NUM=1
  2:  UTOOL_NUM=1
```



Step 40:

Record P[2] so the grippers are in position to clamp onto the finished assembly

Should be P[1]

```
  2:L  P[2] 225mm/sec FINE
```

Step 41:

Add the I/O instruction to close the gripper, clamping the part.

```
  3:  RO[3]=OFF
```

Step 42:

Add the wait command below

```
  4:  WAIT    .50(sec)
```

Step 43:

Add the I/O command below to open the clamp, releasing the assembly

```
  5:  DO[122]=OFF
```

Step 44:

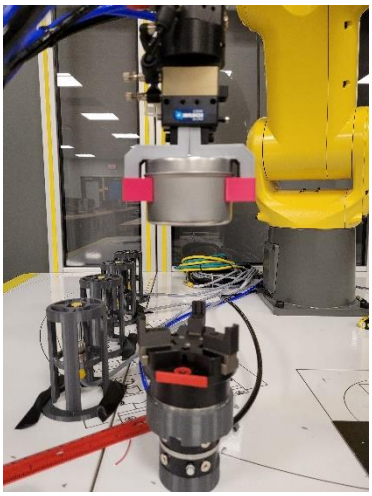
Add the wait command below to give the clamp time to open

```
  6:  WAIT    .50(sec)
```

Step 45:

Move back above the clamp linearly, to clear the clamp and the gripper fingers. Should be P[2]

```
  7:L  P[1] 225mm/sec FINE
```



Step 46:

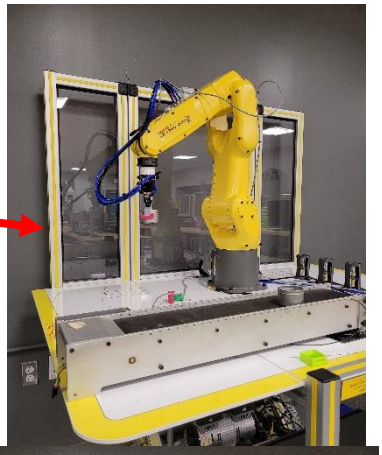
Move to the POUNCE position taught earlier

```
8:J @PR[2:POUNCE] 5% CNT100
```

Step 47:

Move above the drop off location

```
9:J  P[3] 5% CNT100
```



Step 48:

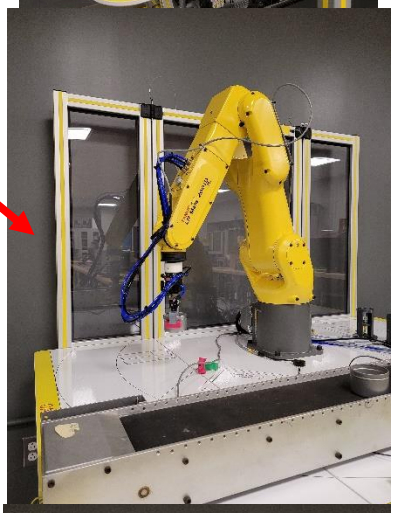
Move to the drop off location

```
10:L  P[4] 225mm/sec FINE
```

Step 49:

Open the gripper to release the part

```
11:  RO[3]=ON
```



Step 50:

Add the wait command to give the gripper time to open

```
12:  WAIT    .25(sec)
```

Step 51:

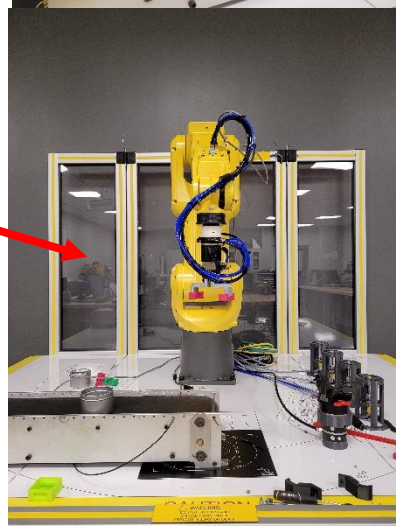
Move back above the drop off location

```
13:L  P[3] 225mm/sec FINE
```

Step 52:

Move to a way point between above drop and home, by rotating just J1 axis.

```
14:J  P[5] 5% CNT100
```



Step 53:

Add the motion instruction below to move to the home position

```
15:J @PR[1:HOME] 5% CNT100
```

All subprograms should now be created. Return to the main program and call over the instructor or lab aids to test the program.

Lorain County Community College

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