1.1 Robot Axis and Movement

NAME: _____ Date: _____ Section: _____

INTRODUCTION

Jointed arm robots are useful for many different tasks because of its range of motion and degrees of freedom. In this activity, you will learn how to move a robotic arm in many different ways and write a program to make the robot write the word "CIM" with **ACCURACY** and **REPEATABILITY**. CIM stands for Computer Integrated Manufacturing.

The method of measurement and positioning we will use to do this is called **RELATIVE COORDINATES.** We will have the robot move the pen "relative" to where it was last. We will also use a method of saving points called **TEACHING**. This is where we type in coordinates without having to move the robot arm.

KEY VOCABULARY

- Relative Coordinates
- Joint movement
- Axis movement
- Work envelope
- Ramping
- Accuracy

- Teach
- Linear move
- Home
- Loop
- End Effector
- End of Arm Tooling (EoAT)

EQUIPMENT & SUPPLIES

- Dobot Magician Lite
- Printed 2 Part Dobot-Lite Field Diagram (see Resources)
- Pen Holder (end effector bracket)

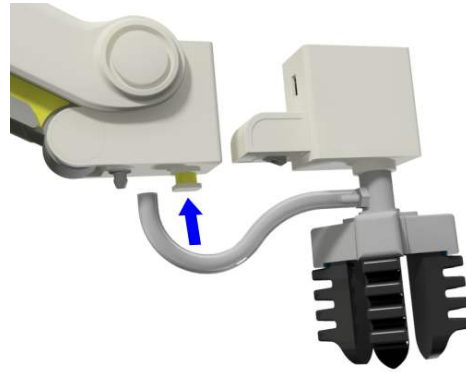- Dobot Lab software
- Pen/Marker
- Masking tape

PROCEDURE

1. **Typical Start Up Procedure**

- Disconnect any existing **END of ARM TOOLING (EoAT).**
- Carefully disconnect any existing vacuum tubes.
- Press and hold the release button on the bottom of the arm and pull off the EoAT.

- Attach the Pen holder as the **END EFFECTOR** or **END of ARM TOOLING (EoAT)** on the Dobot.
- Push the pen holder in until it snaps in
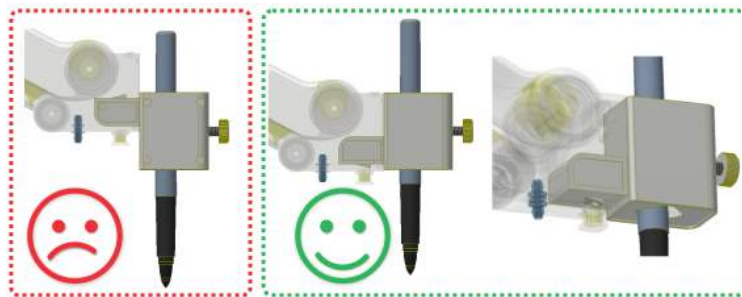
HELPFUL TIPS Do not try to attach the pen holder upside down. The locking tab should be on the bottom

- Plug the 120-240VAC power into an outlet.
- Attach the 12VDC 5A barrel plug of the power supply and USB to the Dobot. Plug the USB into the computer and wait for a connection. **WATCH** and **WAIT** for the robot to completely power on (GREEN INDICATOR)
- Turn on the power to the Dobot (Robot will beep when ready).
- Open DobotLab software.

Power ON
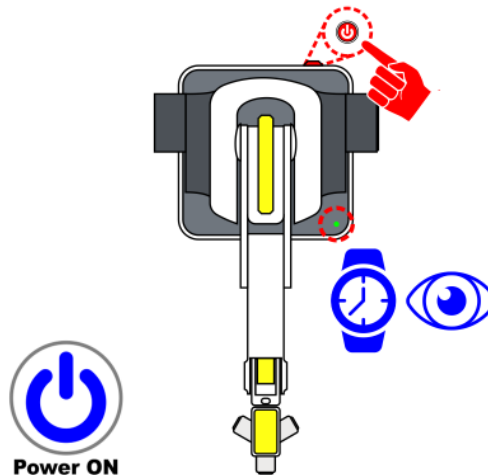
2. Once the Robot's USB is connected to the computer and the robot is powered on, open the DobotLab software
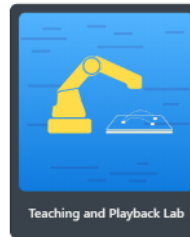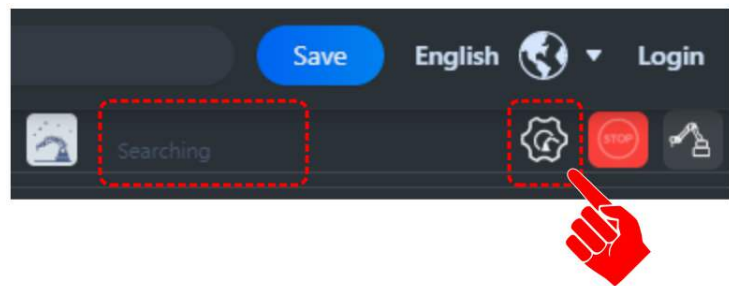
3. Once the software is opened select the Teaching and Playback Lab.

4. Select connect to establish control from the software to the robot. Disconnected should change to Connected and show the COM being used (COM is the USB port being used by the robot)
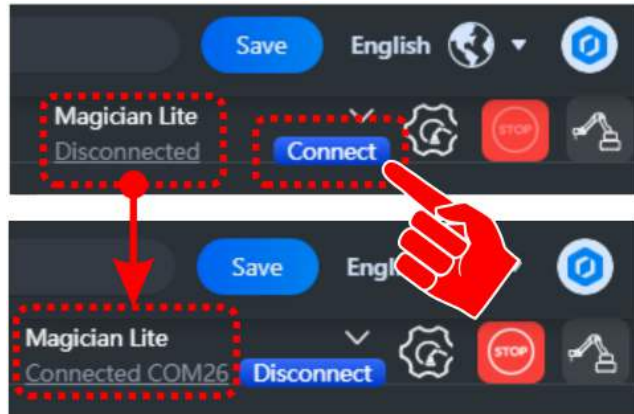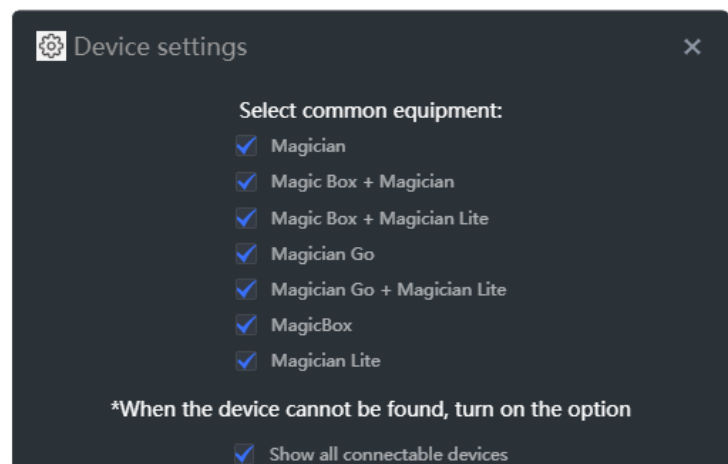
5. NOTE: If no robot is found, the prompt will show as searching

Select the Gear Icon next to the Force Stop Icon

Make sure the hardware you are connected is checked

ARM CONTROL PANEL

6. Select the *ARM CONTROL* Icon to open the arm control panel.

   Before **HOMING** the robot, make sure the robot's **WORK ENVELOPE**, the area in which the robot can reach, is clear.

7. Select the **HOME** icon to start the robots homing process. **HOMING** the robot will return the robot to its initial **HOME** position.
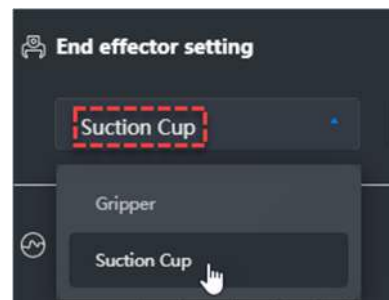
8. Be sure the *Pen* is chosen as the Dobot's **END EFFECTOR** or **EoAT** (End of Arm Tooling).

9. Insert a ball point pen or marker into the holder replacing the one that is there and remember to remove the cap.
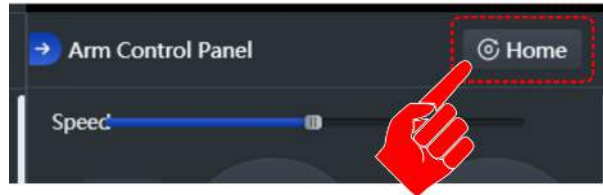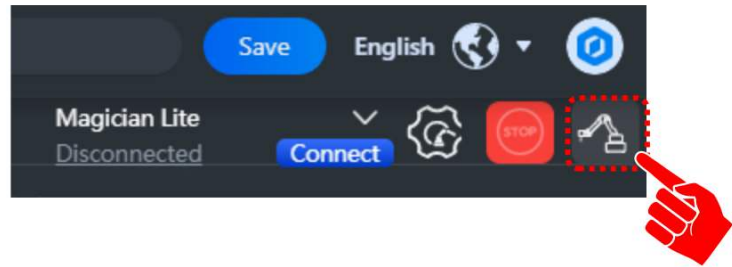
COMMAND PANEL

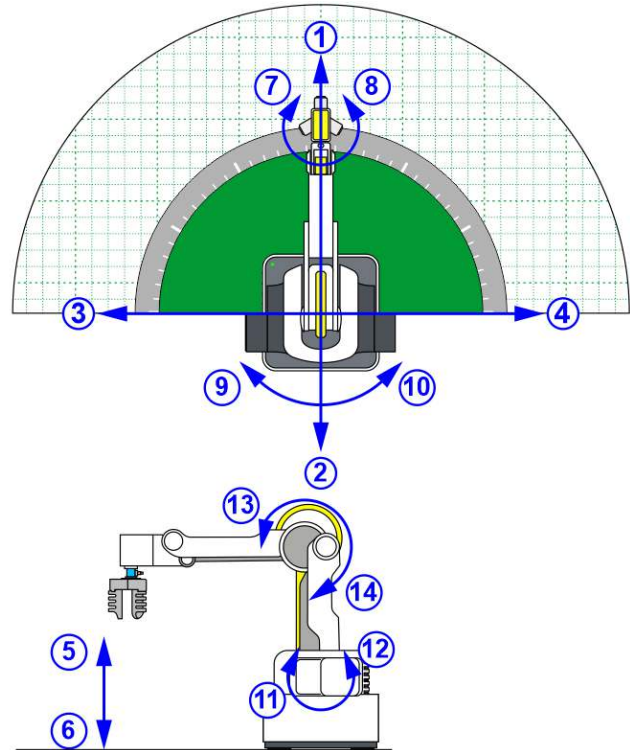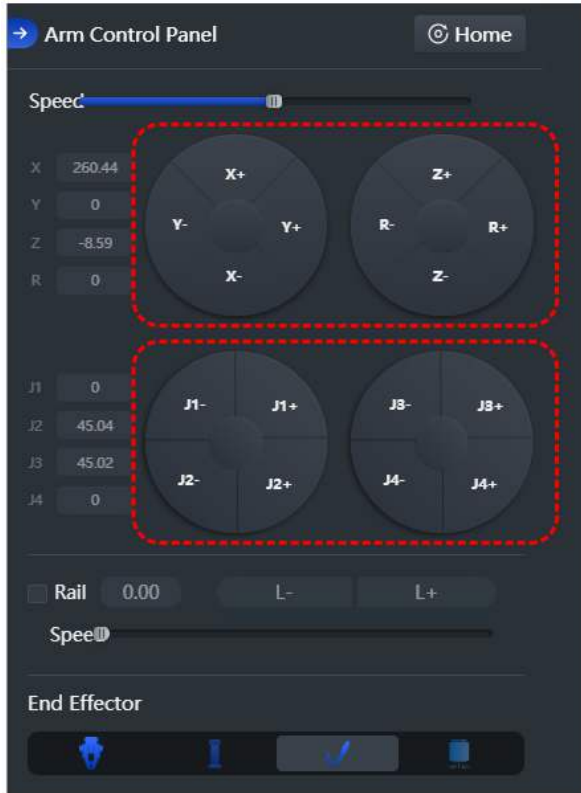10. In the *CONTROL PANEL*, set the end effector as the suction cup (the pen is not an option to select).

ARM CONTROL PANEL

11. Use the Axis and Joint buttons to move the robot around. Using the diagram below, identify the **AXIS MOVEMENT** and **JOINT MOVEMENTS** for the robot (1-14). Be sure to label the them as +/-. (Press and hold ALL 16 options, what do they do, left or right, up or down, in our out....)

12. Using the information you documented on the previous diagram, write down the correct axis/joint button in the first empty column, and a description of what it does in the second.

|	AXIS / JOINT	AXIS / JOINT + / -	DESCRIPTION IN / OUT / UP / DN / LEFT / RIGHT
1	Axis		
2	Axis		
3	Axis		
4	Axis		
5	Axis		
6	Axis		
7	Wrist		
8	Wrist		
9	Waist		
10	Waist		
11	Shoulder		
12	Shoulder		
13	Elbow		
14	Elbow		

13. *Did the axis button work as you expected… did it move the way you thought it would? Explain:*

14. *How do the XYZ movements differ from the J movements?*

15. **MAIN OBJECTIVE:**
    A. Tape together the two parts of the Template along the RED tapeline.

    B. Tape the Template to the table.

    C. Place the Robot on the Template

    D. Handwrite the word "CIM" in pencil on the Dobot Template as shown.

    E. Using the Dobot Lite with the pen end effector, start at point A on your diagram and move the robot from point to point to re-write the word using straight lines. Be sure to pick up the pen between letters.

    F. Send the robot to a home position away from the paper when finished.
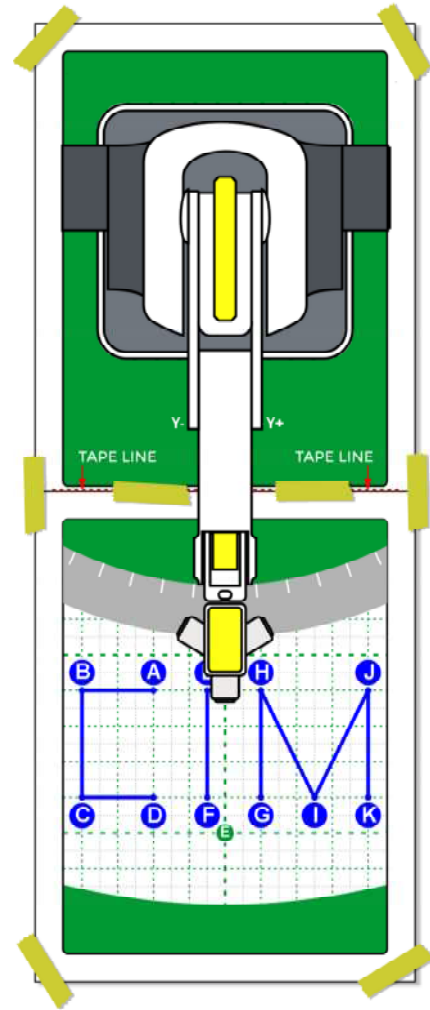
16. *What do you think is this the best way to write the letters CIM (order of movement)? Did you take time into consideration? How?*   17.

When moving in the z-axis, try to put a light pressure on it when you write, or it may tear the paper or break the tip. The pen is NOT spring loaded; You have to have a soft touch or the paper my tear or the pen may be caught on the paper and slide the robot's base. It may be a good idea to put a piece of cardboard under the paper to give it a softer surface to write on.

17. For this activity, we will use a combination of recorded and taught positions. We will teach the robot the points shown using actual coordinates. The big **GREEN** squares on the paper are equal to about 20mm, this will help us plan our letters.
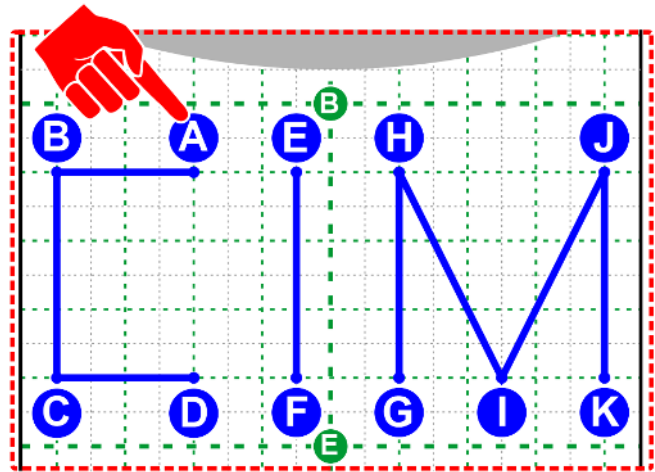

18. Line Segment lengths are as follows:

AB = 40mm	BC = 60mm	CD = 40mm
EF = 60mm	GH = 40mm	*HI = 68mm
*IJ = 68mm	JK = 60mm	

19. Make sure you are in the **Teach and Playback** lab.

We will use this lab to **RECORD** and **TEACH** the robot the points we want it to go to write the word CIM.

There are two methods to RECORDING a point.

Method 1: **RECORDED** points can be found using the unlock button on the robot's arm. When the unlock button is pressed, the arm becomes free to manually move to a new location. The location is automatically **RECORDED** and added as a step in the program when the unlock is released. Movements in between the steps (while the button is held) will not be recorded.
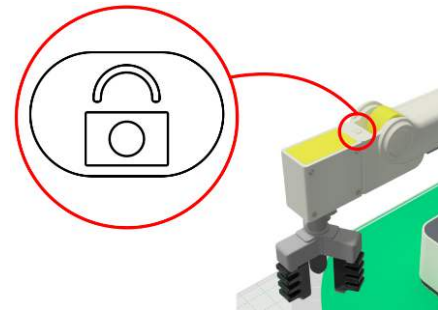
Method 2: **RECORDED** points can also be found by manually driving the robot to a position from the *Arm Control Panel* and selecting Save Point when the **EoAT** is at the desired location

TEACHING points is the process of manually typing in the XYZ coordinates if they are known. We often use this method to **TOUCH UP** points (round them to whole numbers, change them to a known number, or duplicate positions from previous steps that should not have changed).

HELPFUL TIPS Always start a program with a safe/clear HOME position. Home is a position that is up and away or clear of any obstacles.

20. Using the XYZ buttons on the *Arm Control Panel*, move the robot to a safe **HOME** position. We can refer to this as "HOME".

    -Touch up (round) the coordinates as needed. Ignore the last number in the coordinate's window ®, as this stands for "rotation or roll". It is not used with the pen..
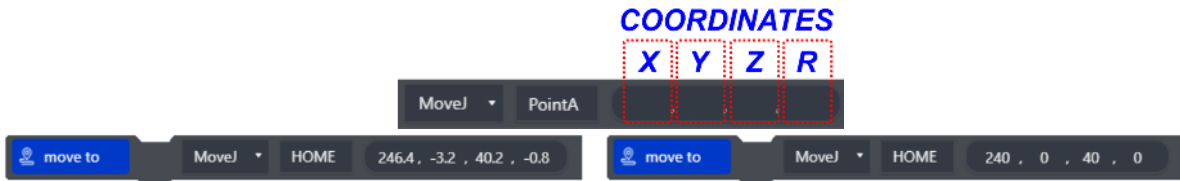
    -Record these values on the chart below.

    Using the XYZ buttons on the *Arm Control Panel*, move the robot to a point above **POINT A**. We can refer to this as AB-A (Above Point A). Do not touch the paper yet with the pen! - Record this value on the chart below.

21. You can also press the "Lock" button on the arm and it will **RECORD** the point where the pen is when the button is released. If the point has moved a bit, you can touch up the points by **TEACHING** them in the XYZ coordinates window.
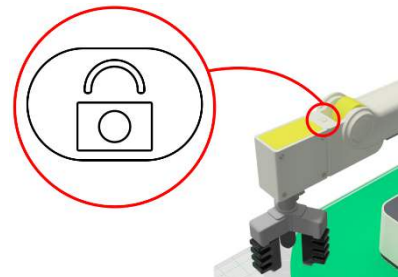
Record the values to create the letter CIM on the chart below.

STEP	POSITIONS	X =	Y =	Z =
1	HOME			
2	AB-A			
3	AT-A			
4	AT-B			
5	AT-C			
6	AT-D			
7	AB-D			
8	AB-E			
9	AT-E			
10	AT-F			
11	AB-F			
12	AB-G			
13	AT-G			
14	AT-H			
15	AT-I			
16	AT-J			
17	AT-K			
18	AB-K			
19	HOME			

Click in the cell with the "P" for each point to create a descriptive name for each position. See Example Below "AT-A" (EoAT is At Point A).


Movements can either be *MoveJ, MoveL, or Jump*. We will get to *Jump* in later activities.

MoveJ movements always have an arc to them. We use them for movements that can have less accuracy. Example: when traveling from home to an above position or when traveling from an above to another above position.

MoveL movements are linear. We use them when moving down to a point or object, or when moving away from a point or object to ensure movement accuracy. **All of the lines to create the letters for CIM should use *MoveL* movements**

If TEACHING the positions, select the Save Point tool to create 19 empty steps. Using the chart you created, fill in the names of the steps and the XYZ values.

Note: The coordinates automatically used for the Save Point is the current location of the **EoAT**
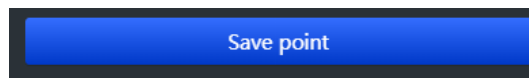
You may also right click on an existing step and select insert to create an additional step

If RECORDING the positions, the positions are automatically created as well as filled in. These positions should be touched up.
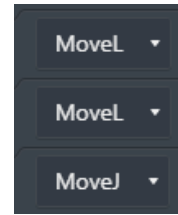
Touch Up Example 1: AB (Above) positions should only have a different Z value. The X and Y should be the same.

Touch Up Example 2: All AB (Above) positions should have the same Z value. All AT (At) positions should have the same Z value.

Touch Up Example 3: The positions for AT-A and AT-B should only change on one axis.
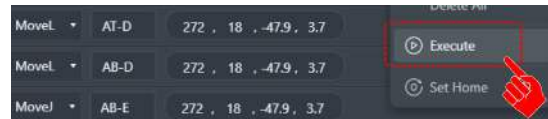
22. Change the Motion Styles to *MOVEJ* and *MOVL* where appropriate.

23. It is beneficial to step through (run one line of code at a time) a program to find any errors. Right click on each step one at a time (from the top down) and select EXECUTE. This will run just that step.
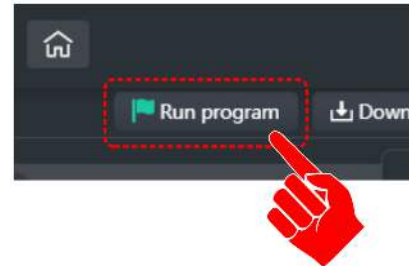
   If there are errors in a step, update the XYZ coordinate values until they are correct.

    Repeat this process for each step.

24. Once each individual step is verified, we can try to run the entire program. Select the first line of code, ensure there are no obstructions in the robots path, and select the RUN PROGRAM option at the top of the screen.

25. Now that we know all the points are correct, we must change the Z value so that it writes on the paper. To do this, follow these steps:

A. Select the first AT line, right click & use **EXECUTE** to move the robot to point A.

B. Change the Z by increasing its value -2mm at a time and hitting *RunSelected* until the pen just touches the paper. You may also use the Z- from the Arm Control Panel

C. Now change all the Z values where the pen must actually write a line. Leave the AB (Above) value alone when it moves from letter to letter.
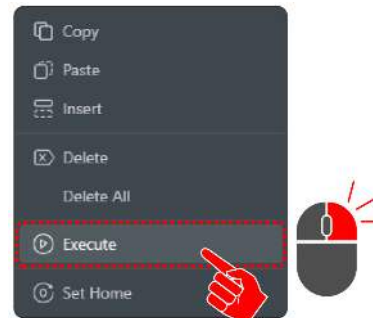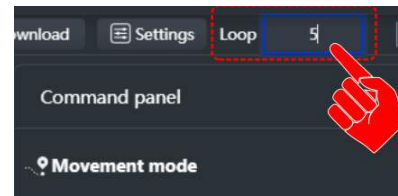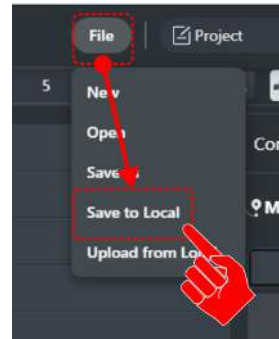
26. Using the *Loop* button, change it to 5 and watch your program **LOOP** five times when you hit the start button.

Save your work.

Select **File** from the top tool bar.
Select **Save to Local** to save your project on to the computer.

Let's check the **ACCURACY & REPEATABILITY** of our robot. Get another grid portion of the template either replace old one or add it on top of the old one. Be sure to tape it to your work surface. Now run your program again. Check all the lines closely. *How accurate was your robot at reproducing the word CIM five times? Describe it below.*

How accurate and repeatable was your robot and program? Be sure to describe both terms.
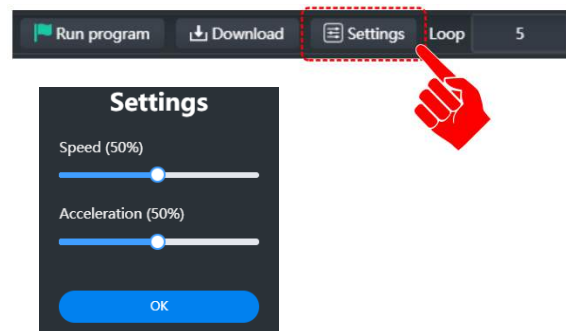Response:

What happens to the **ACCURACY & REPEATABILITY** if you increase speed to 75? Try it and see.

Please do not increase speed above what is specified by your instructor.

To change the speed of your program, select the settings tab at the top of the screen.

Speed Adjustment: What happened when you changed the speed? Be specific.
Response:

CONCLUSION

1. What does it mean to touch up a program?

2. Explain completely the difference between MOVJ and MOVL Motion Styles.

*3. Does speed influence **ACCURACY** or **REPEATIBILITY** of your robot? Describe how.*

4. What would be the effect on the robot's accuracy at higher speeds if you greatly increased the mass of the pen?

5. After completing this activity, how would you define the difference between a robot's accuracy versus its repeatability?

6. Why do we use AB (Above) positions before going to AT (At) Positions? Explain fully.

7. What is the purpose of a HOME position?

GOING BEYOND

Finished early? Try drawing one of the options below. When finished, show your instructor and have them initial on the line.

Teacher
Signature

_____   1. Teach the robot to make a barcode with the pen.

_____   2. Teach the robot to write your name.

_____   3. Teach the robot to write arcs (can you figure Arc movements out?).