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 CONCEPTS

- Different ways that robot arms can move: **Move Linear** and **Move Joint.**
- Differentiate between **absolute** and **relative** coordinates.
- Differentiate between **teaching** and **recording** points.
- Starting up and connecting the Dobot Magician.
- How to utilize a robot arm to move through a group of points by using the pen **end effector** and writing the word CIM.
- How to use DobotStudio Teach and Playback Module.

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
- Dobot Field Diagram
- Pen end effector bracket
- DobotStudio software
- Pen
- Masking tape

PROCEDURE

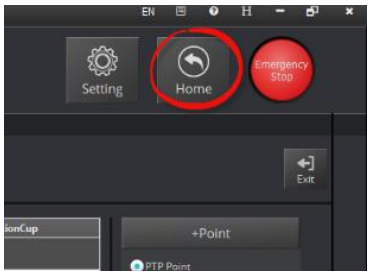
Caution: NEVER wire anything to the Dobot Magician while it has power on. ALWAYS turn it off before making connections or damage to the robot could occur.

1. **Typical Start Up Procedure**

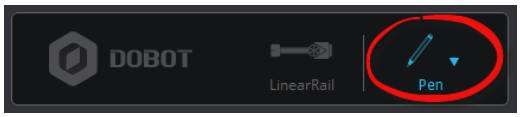
- Attach the Pen tool as the **END EFFECTOR** or **END of ARM TOOLING** on the Dobot.
- Plug the 120-240VAC power into an outlet.
- Attach the 12VDC 7A barrel plug of the power supply and USB to the Dobot.
- Plug the USB into the computer. and wait for a connection.
- Turn on the power to the Dobot.
- Open DobotStudio software.

2. Open DobotStudio software and connect the robot in the software.

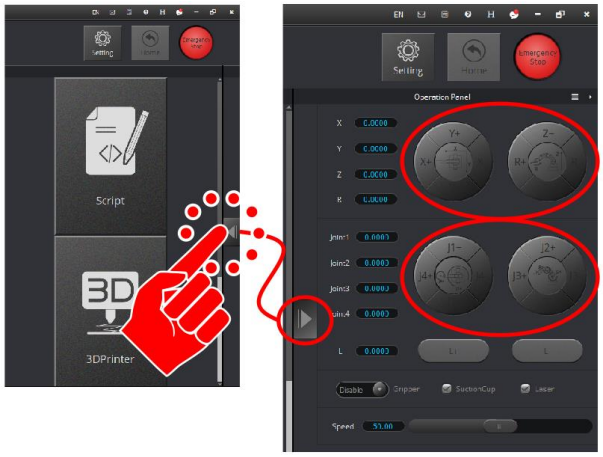
3. **HOME** the robot making sure the robot's **WORK ENVELOPE**, the area in which the robot can reach, is clear. **HOMING** the robot will return the robot to its initial **HOME** position.

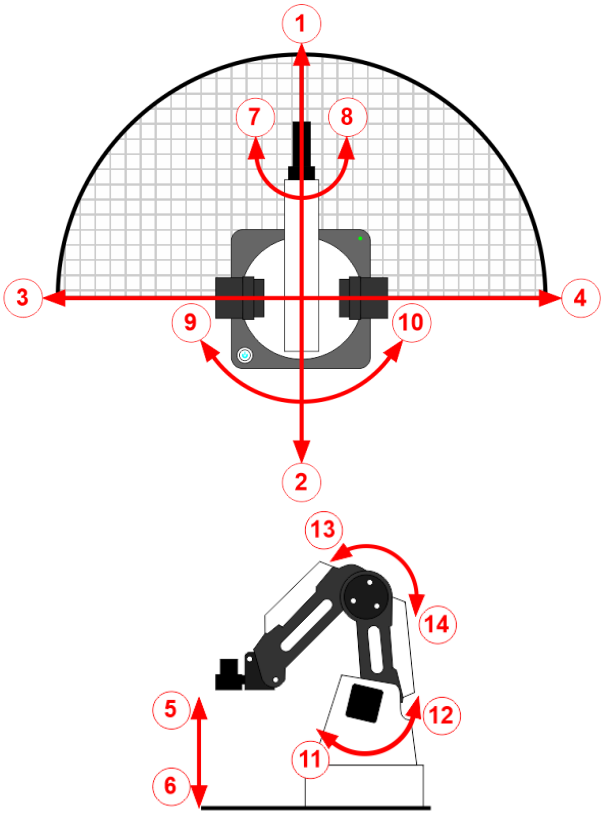


4. Be sure the ***Pen*** is chosen as the Dobot accessory.



5. Open the manual control panel and use the Axis and Joint buttons to move the robot around. Using the chart diagram provided, identify the **AXIS MOVEMENT** and **JOINT MOVEMENTS** for the robot (1-14). Be sure to label the them as +/-.


Script
3D
3DPrinter
Operation Panel
Disable
Gripper
SuctionCup
Laser
Speed


1
2
3
4
5
6
7
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10
11
12
13
14

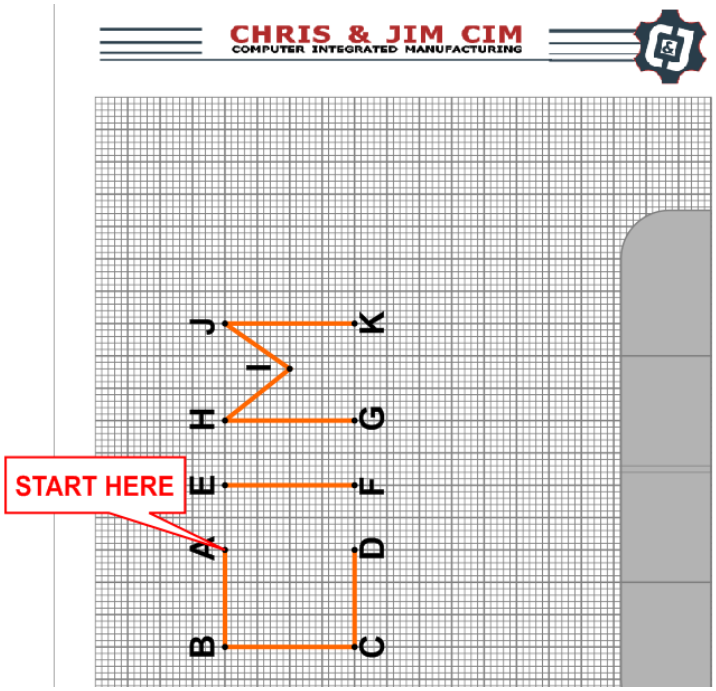
Using the information you documented on the previous diagram. Write down the correct axis/joint button in the first empty column, and a description of what it does in the second.

		AXIS / JOINT + / -	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		

6. Are the axis defined as you expected? Explain:

7. How do the XYZ movements differ from the J movements?

8. **MAIN OBJECTIVE:**
First, handwrite the word "CIM" in pencil on the Dobot Template as shown (see step 10 for segment dimensions). Second, using the Dobot 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 and send the robot to a position away from the paper when finished.



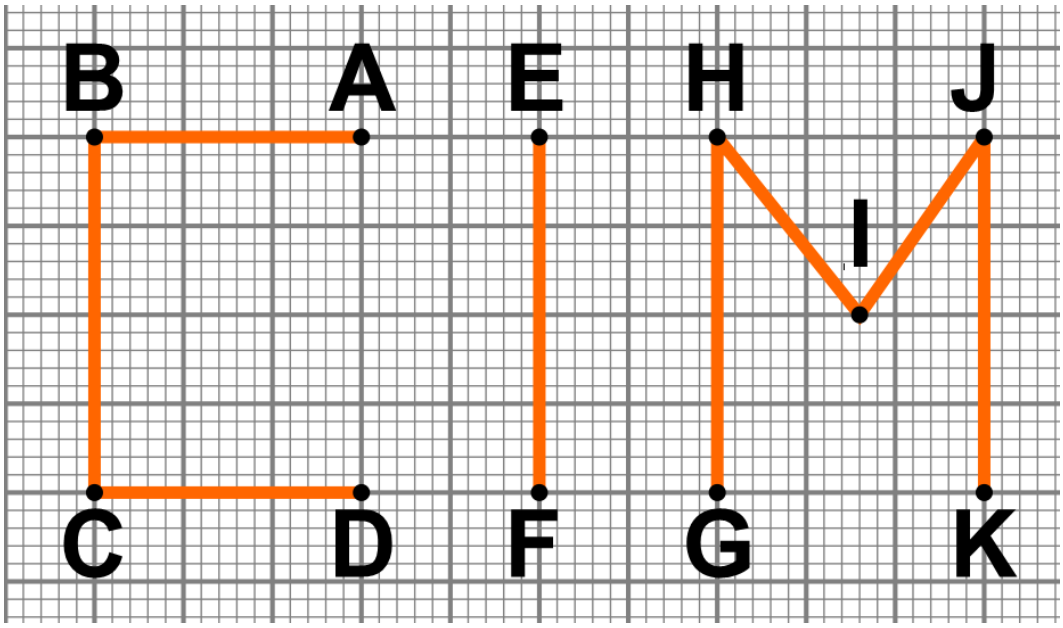
9. *What do you think is this the best way to write the letters CIM (order of movement)? Did you take time into consideration? How?*

HELPFUL TIPS

When finding the initial points for the pen, keep the cap on the pen.

Notice that the pen is spring loaded; this gives the pen a softer touch to the paper and allows for the same points to work on an uneven or irregular surface. This also allows the pen not to smash into the table and break it. When moving in the z-axis though, try to put just light pressure (about half of the spring position) on it when you write, or it may tear the paper or break the tip.

10. 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 squares on the paper are equal to about 10mm, this will help us plan our letters.

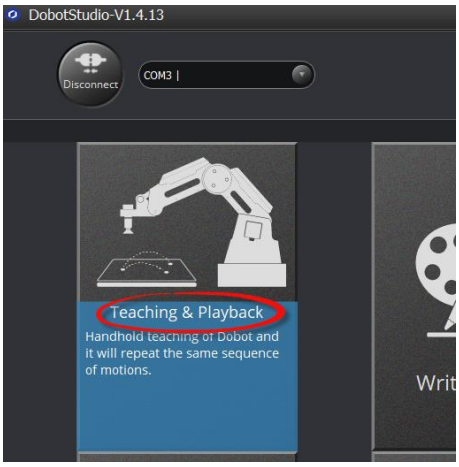


11. Line Segment lengths are as follows:

AB = 30mm	BC = 40mm	CD = 30mm
EF = 40mm	GH = 40mm	*HI = ???mm
*IJ = ???mm	JK = 40mm	

**what is the length of these two line segments? How do you know? Explain below.*

12. Now open the **Teach and Playback** module.

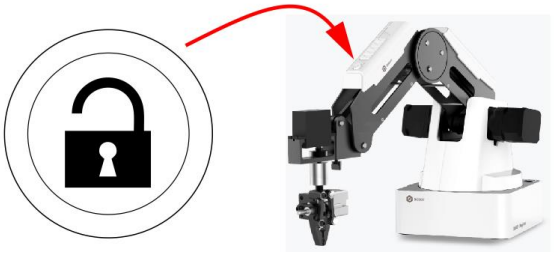


We will use this module to **RECORD** and **TEACH** the robot the points we want it to go to write the word CIM. **RECORDED** points are points found using the lock button on the robot's arm. By **TEACHING** points, we just type in the XYZ coordinates, and we do not have to move the robot around. This is used in industry because it is much faster and efficient when coordinates or the relationship between points is known.

13. Using the XYZ buttons on the *Operation Panel*, you can move the robot to a point above **POINT A**. Do not touch the paper yet with the pen! Write down the XYZ values you see in the software below:

X = _____ Y = _____ Z = _____

14. You can also press the "Lock" button on the arm, and it will **RECORD** the point where the pen is. If the point has moved a bit, you can just enter the three points from step 13 into the XYZ columns and name it Point A. Ignore the *R* and *PauseTime* column for now.



HELPFUL TIPS

Double Click in the empty cell in the **Name Column** for each point to create a descriptive name for each position. See Example Below "PointA"

	MotionStyle	Name	X	Y	Z	R	PauseTime
1	MOVJ	Point A	255.31	34.26	-55.0	29.8444	0.0

15. Change the Motion Style to *MOVL*. This will make the robot move in straight lines. This is called a **LINEAR** move.

16. Select step one and use the options menu to copy and paste that position.

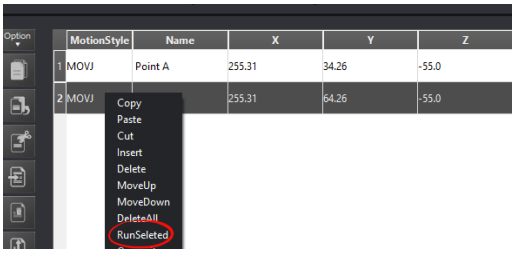
17. Now change those X & Y values to match the values of letter B in the sketch from step 15. Keep in mind that point B is 30 mm in the positive Y direction **RELATIVE** to **POINT A**. What are **POINT B's** coordinates? Leave Z the same!

X = _____

Y = _____

Z = _____

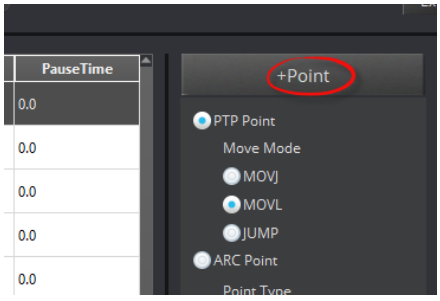
18. Right click on point B and select *RunSelected* and see if it moves where you want it to. Change the values for X and Y until it does.



19. Fill out the chart below, then complete the program to write the letters “C I M” Leave the height of the pen at some number that is above the paper, and we can adjust that later.

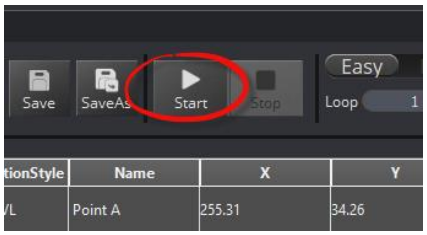
Name	X	Y	Z
Point A			
Point B			
Point C			
Point D			
Point E			
Point F			
Point G			
Point H			
Point I			
Point J			
Point K			

20. Now *Copy* and *Paste* or use the “*+ Points*” dialog to add the new positions. Remember that segments HI and IJ move in two axes and this needs to be reflected in the code! It’s a good idea to use “*RunSelected”* after each line to be sure it’s moving where you want it to.



21. Press the start button and see if it runs through your complete program correctly.

Edit all the points X & Y values until it moves correctly.



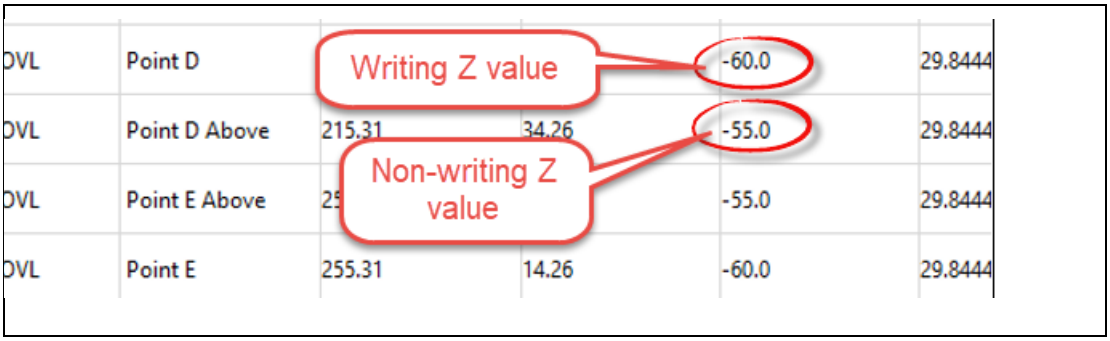
22. Now that we know all the points are correct, we must change the Z value so that it writes on the paper. To do this, follow these steps:

    A. Select the first line, right click & use *RunSelected* 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.

    C. Now change all the Z values where the pen must actually write a line. Leave the value alone when it moves from letter to letter.

23. After changing all Z values, Hit the "*Play*" button to run your program and see what happens. What happened when the pen moved between letters? That diagonal move is called **RAMPING**, and we don't want that. To fix that, select the end point of the letter C in CIM, right click, choose c*opy,* and then right click and choose *paste.* See how it added a second Point D? Change the Z value of the second one back to the higher position so it looks like the picture below. Do the same for the first point in the letter I in CIM. This way it draws the line in the air, not on the paper! Your numbers may vary.



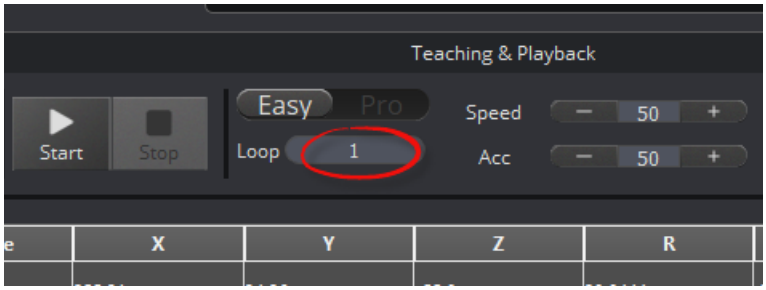
Now do the same for the move between points the letters I and M of CIM.

24. We always want our robot to start in the air, and finish in the air so let's make that happen.

    Add a Point A above using the *options* or *right click menu* as the first line of code, and do the same at the end for Point K. This will make the robot start and end the program in the air.

25. Now run it, and it should draw your letters correctly.

26. Using the *Loop* button, change it to 5 and watch your program **LOOP** five times when you hit the start button.

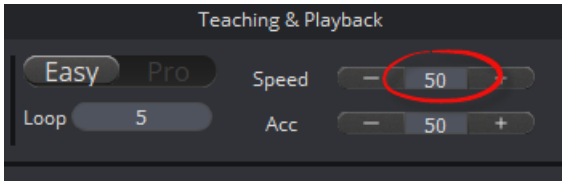


27. Save your work.

28. Let's check the **ACCURACY** of our robot. Get another piece of graph paper and replace 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.*

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

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



CONCLUSION

1. *Why are **RELATIVE COORDINATES** important in robotics? Explain.*

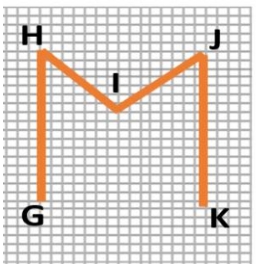
2. *Explain the difference between MOVJ and MOVL MotionStyles.*

3. *Does speed influence **ACCURACY** with your robot?*

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

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

6. *How would you calculate point I in this activity using mathematics if it were not given?*



GOING BEYOND

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

_____ 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.