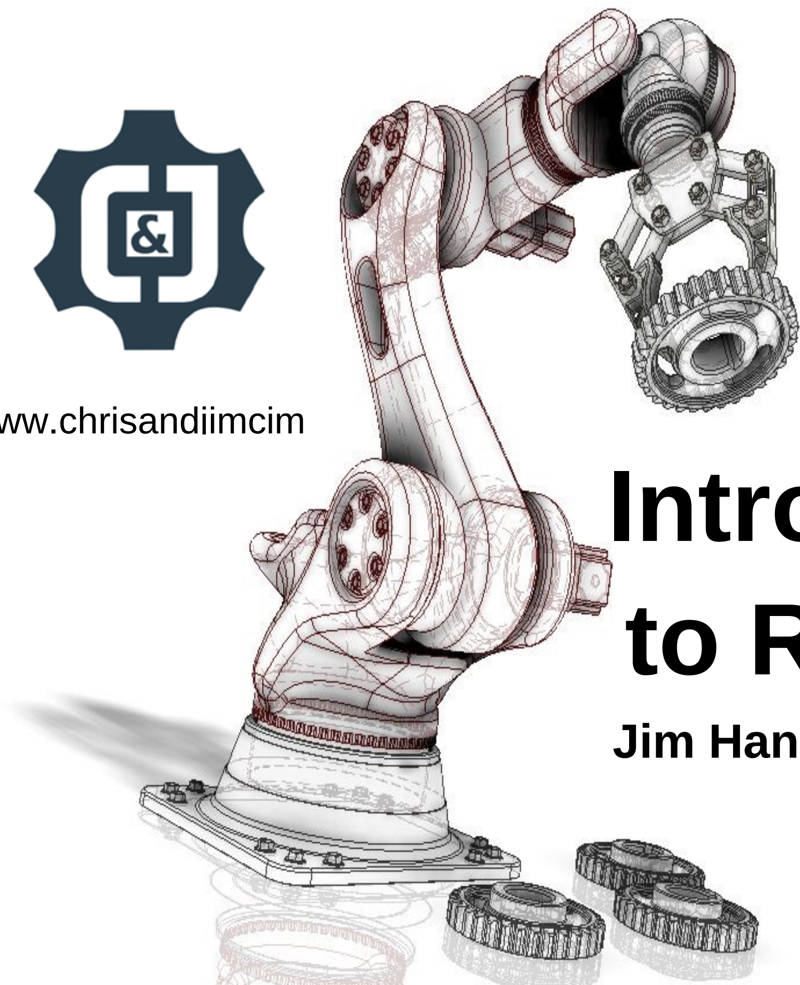


www.chrisandjimcim

Introduction to Robotics

Jim Hanson & Chris Hurd

Dobot USA

www.dobot.us

Foreword

It has been my pleasure to get to know Chris Hurd the past few years. He has been a great resource for me as I have helped our traditionally industrial company move into the educational space. His energy and passion for education is truly inspiring and contagious! He has helped me understand education, teachers and create stronger robotics educational programs.

Chris Hurd has a wealth of expertise and knowledge in both education and technology. He has taught high school for over 25 years and is a Project Lead the Way master teacher. He was awarded the PLTW National Engineering Teacher of the Year in 2016. On top of that he was the Technology Department Head of the Year for the state of New York and Technology Teacher of the Year in 2010 and 2011. I can go on and on, but the true testament to his abilities is this curriculum. As an automation engineer myself, I can say that this curriculum is exceptional. It is well thought out and a student that goes through it will be well on their way to enter the work force or continue their education in engineering and robotics.

As I mentioned, I am new to education. My background is in Mechanical Engineering and since school I have worked in industrial automation for In-Position Technologies. Over the course of the 20+ years we have been in business we have helped countless companies implement automation solutions. Due to rising labor costs, improvements in automation technology and more affordable pricing, there has never been a greater demand for automation than we have today – especially in the field of robotics. As we have helped companies add robots into their production processes, we have seen a need to improve the way our workforce is educated. In short, we need more robots in our schools!

Robots are not only changing the way we do manufacturing, but our entire workforce. Transportation and logistics are on the brink of experiencing a massive change due to self-driving vehicles. We have automated farming equipment harvesting crops, robots aiding surgeons in hospitals, robot bartenders, robotic construction equipment and artificial intelligence programs writing music and trading stocks. We even have robots in the home – vacuuming our floors, controlling our air conditioning and weeding our gardens. Even Amazon Alexa is a robot that tells us jokes, plays us music and shops online. Robots are everywhere, but our education has not prepared us for this day. We need improved programs where computer science, engineering, and robotics are taught as core curriculum.

For this reason, we partnered with Dobot to bring the Dobot Magician into the US market. It is a ground breaking robot that brings the functionality of industrial robots into the classroom on a school's budget. Dobot has done a fantastic job of creating software that makes this robot simple enough that a kindergartner can use it yet sophisticated enough to be used by university students. I am pleased to say that with the additional of Chris's new curriculum the Dobot Magician will not only be easy to use but easy to integrate in the classroom. Easy to supplement current technology courses. Easy for teachers to start their school's first robotics course.

I hope you enjoy this curriculum and thank you for helping your students prepare to thrive in this technological age, your efforts to do not go unnoticed! Last of all, thank you Chris for all of the time you have dedicated to education and furthering robotics programs across the country.

Christian Hunter
Engineer
In-Position Technologies
www.iptech1.com
www.dobot.us

Introduction

This curriculum was designed to teach high school and college level students the basics of robotics, as used in industry. Many video tutorials and answers on using the Dobot Magician in the classroom can be found at ***www.chrisandjimcim.com***.

Table of Contents (List of Activities & Presentations)

Students learn about different types of robots and how they move. Acts as an investigation with the Dobot Magician and its motions and use.
Essential questions answered in this activity include:

- What's the difference between Move Linear and Move Joint?
- What's the difference between absolute and relative coordinates?
- What's the difference between teaching and recording points?
- How do you start up and connect the Dobot Magician?
- How do you utilize a robot arm to move through a group of points by using the pen end effector and writing the word "CIM"?
- How do you use the DobotStudio Teach and Playback Module?

Students learn what industrial robotic arms are used for and apply what they learn by doing pick and place routines with the Dobot magician.
Essential questions answered in this activity include:

- How does a robot perform a pick and place operation?
- What end effector works best?
- What are Pick and Place conventions in industry?
- How do I attach the Mechanical Gripper to the Dobot?
- How do I record positions with the Dobot?
- How do I easily edit a program in DobotStudio?

Students learn how to simplify repetitive routines by using Jumps and Loops. Using the Dobot Magician, students use jump and loop commands to complete a dipping operation that simulates anodizing.
Essential questions answered in this activity include:

- What is anodizing?

- What is a JUMP, and how is it easier?
- What is a LOOP, and how does it make my life easier?
- When would I use a Jump or a Loop?
- How does a vacuum gripper work?

Students develop an understanding of using outside inputs to make a robot start routine. In this investigation they use a digital switch to tell a robot when to start.
Essential questions answered in this activity include:

- What is Tool Center Point (TCP)?
- What is a digital input?
- What's the difference between analog and digital inputs?
- What is a resistor? A pull-down resistor?
- Why do I need a pull-down resistor?

Students develop an understanding of palletization, and how robots manipulate rectangular objects to fit together on a pallet. Using the Dobot Magician, students complete a palletization operation.
Essential questions answered in this activity include:

- What is palletization, and why is it important?
- What is roll angle? How do I calculate it if I have to?
- How do I make the Dobot Magician do a roll angle?
- How do I complete a palletization operation with a Dobot Magician?

Students develop an understanding of how robots can communicate with one another through the use of inputs and Outputs. Students use two Dobot Magicians to complete a two robot operation without timing.
Essential questions answered in this activity include:

- How do I make a robot send a signal?
- How do I get a robot to receive a signal?
- How is this done in Dobot Studio Software?
-

Students develop an understanding of how robots can communicate with other devices, like microcontrollers, through the use of inputs and outputs.
Essential questions answered in this activity include:

- How do I get a robot to send and receive a signal?
- How do I make my microcontroller send and receive signals?
- How is this done in Dobot Studio Software?
- How do I wire the hardware to make this happen?
- How do I troubleshoot a complex robotic system?

Students develop an understanding of workcells and the interaction of different machines to complete a manufacturing process.
Essential questions answered in this activity include:

- How do you integrate robots and other part of a work cell to complete a given task?
- How do you safely communicate between a microcontroller and a robot?
- What are the different types and styles of inputs and outputs needed to complete your given tasks?
- Which end of arm tooling is most appropriate for your work cell?
- Where would it be appropriate in your programming to use either absolute or absolute programming?
- What components of the DobotStudio software did you need to complete this task?

What is the difference between a robot's accuracy and repeatability?

Advantages of Using the Dobot Magician

After thorough testing for almost a year, we have found the following advantages in our classrooms:

- Multiple ways to program, including a Blockly version that can be used by younger PLTW students all the way down to the elementary level. DobotStudio software also allows you to program the robot in a similar manner as a real industrial arm, via XYZ coordinates.
- The Dobot can be programmed very easily by dragging the arm and clicking a button to store XYZ coordinates.
- The DobotStudio software is constantly updated, and every time I have asked for a feature to be fixed or added, it has been addressed in the next version.
- Dobot Studio software is a free download and can be installed for free on every computer in your classroom without any licensing problems.
- The Dobot hardware connects to the software first time every time.
- Dobots come pre-built; no worrying about whether or not your students will build them correctly.
- Dobot Magician is very accurate; actually, more accurate than the box states. About +/- 0.17mm. http://chrisandjimcim.com/how-accurate-is-the-dobot-magician/ This is a factor of at least 100x's better than other ones we have used in class before. The Dobot's repeatability day after day is superior as well.
- The Dobot has more than 15 inputs & outputs, many more than any robot we have ever used in our classroom. The Dobots I/O's are varied and can deal with 3.3, 5 and 12V, as well as servo motors.

- The Dobot uses highly accurate stepper motors, not hobby servos.
- The Dobot's electronics are all enclosed and protected.
- The Dobot has many end effectors, just like an industrial arm. These include a 3D printer, laser engraver, suction cup gripper, pneumatic gripper, and a pen.
- The Dobot is machined aluminum with plastic covers and is very well built, is very sturdy and very durable.
- The Dobot's payload and range of motion is much greater than that of other robots we have used in the classroom.
- The Dobot has many industrial grade accessories like a slidebase, vision system and conveyor.

Curriculum Standards

Standards for Technological Literacy

The Standards for Technological Literacy (STL) were developed by the International Technology and Engineering Educators Association (ITEEA) and are available as a complete download for free here: https://www.iteea.org/File.aspx?id=67767

2-W	*Standard:* Students will develop an understanding of the core concepts of technology. *Benchmark:* Systems thinking applies logic and creativity with appropriate compromises incomplex real-life problems.
2-Z	*Standard:* Students will develop an understanding of the core concepts of technology. *Benchmark:* Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.
2-AA	*Standard:* Students will develop an understanding of the core concepts of technology. *Benchmark:* Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
2-BB	*Standard:* Students will develop an understanding of the core concepts of technology. *Benchmark:* Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
8-H	*Standard:* Students will develop an understanding of the attributes of design. *Benchmark:* The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype.

8-I *Standard:* Students will develop an understanding of the attributes of design.
Benchmark: Design problems are seldom presented in a clearly defined form.

8-J *Standard:* Students will develop an understanding of the attributes of design.
Benchmark: The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.

8-K *Standard:* Students will develop an understanding of the attributes of design.
Benchmark: Requirements of a design, such as criteria, constraints, and efficiency,sometimes compete with each other.

9-I *Standard:* Students will develop an understanding of engineering design.
Benchmark: Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9-J *Standard:* Students will develop an understanding of engineering design.
Benchmark: Engineering design is influenced by personal characteristics, such as creativity,resourcefulness, and the ability to visualize and think abstractly.

9-K *Standard:* Students will develop an understanding of engineering design.
Benchmark: A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

9-L *Standard:* Students will develop an understanding of engineering design.
Benchmark: The process of engineering design takes into account a number of factors.

11-N *Standard:* Students will develop the abilities to apply the design process.
Benchmark: Identify criteria and constraints and determine how these will affect the design process.

11-O *Standard:* Students will develop the abilities to apply the design process.
Benchmark: Refine a design by using prototypes and modeling to ensure quality, efficiency,and productivity of the final product.

11-P *Standard:* Students will develop the abilities to apply the design process.
Benchmark: Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.

11-Q *Standard:* Students will develop the abilities to apply the design process.
Benchmark: Develop and produce a product or system using a design process.

11-R *Standard:* Students will develop the abilities to apply the design process.
Benchmark: R.Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

12-P *Standard:* Students will develop the abilities to use and maintain technological products and systems.
Benchmark: Use computers and calculators to access, retrieve, organize, process, maintain,interpret, and evaluate data and information in order to communicate.

Next Generation Science Standards

The **Next Generation Science Standards** is a multi-state effort to create new education **standards** that are "rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked **science** education." More information can be found here: http://www.nextgenscience.org/ pg 102

HS.ETS1.2	Engineering Design
	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS.ETS1.3	Engineering Design
	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
DCI - ETS1.B	Engineering Design - Developing Possible Solutions
	When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)
DCI - ETS1.C	Engineering Design - Optimizing the Design Solution
	Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary to HS-PS1-6)
	Science and Engineering Practice - Planning and Carrying Out Investigations
	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
	Science and Engineering Practice - Using Mathematics and Computational Thinking
	Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
	Crosscutting Concepts - Systems and System Models

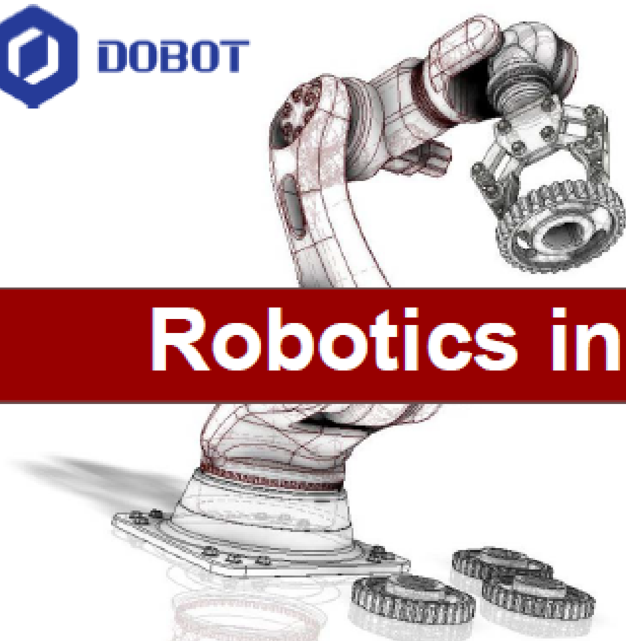
- A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
- Systems can be designed to do specific tasks.
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.
- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HSETS1-3)

Presentation: Robotics in Industry – Introduction

DOBOT



Introduction

Robotics in Industry

www.ChrisandJimCIM.com

Industrial Robotics

Industrial Robotics: technology dealing with the design, construction, and operation of robots in automation

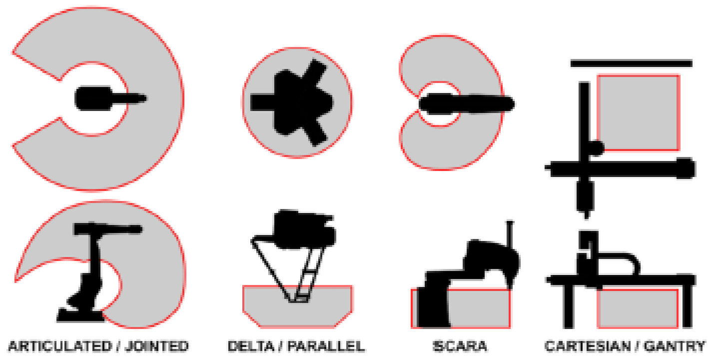
Reasons for using Industrial Robotics:

- -Repetitive motions
- -Complex operations
- -Increased production
- -Reduced Labor Cost
- -Hazardous Tasks
- -Increased Consistency

Example Applications: Welding, Painting, Handling Material, Inspecting, Packaging, Assembly

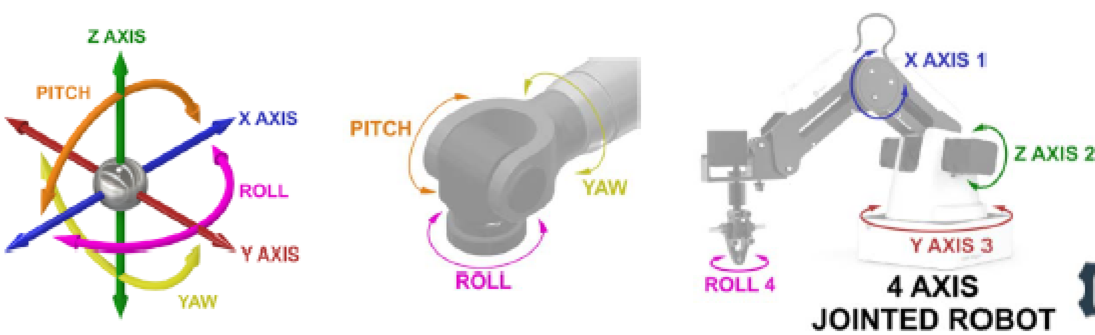
Robotics Work Envelope

Work Envelope: Defined as the range and area each robot may work within. The shape and size of the envelope is determined by a robot's degrees of freedom, style of movement (linear or rotation) and size/range.

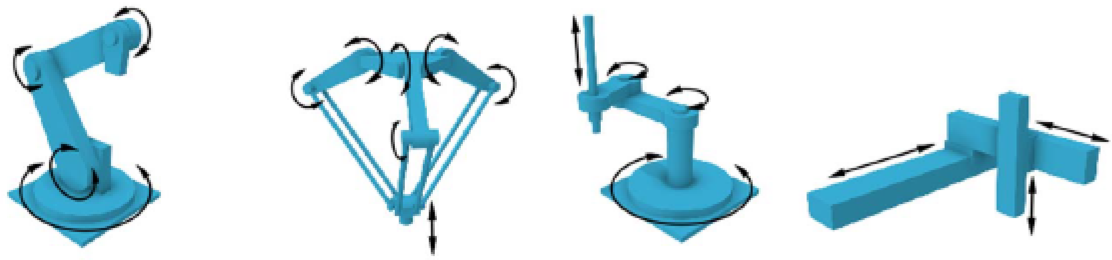


Degrees of Freedom (DoF)

Degrees of Freedom (DoF): Defined by the number of joints that can be controlled and provide each robot design with its range of motion. Industrial robots can have up to six degrees of freedom. Robots with more degrees of freedom have a greater range of motion and a wider scope of application.



Types of Industrial Robotics



Articulated/ Jointed

Parallel/ Delta

SCARA

Cartesian/ Gantry

Definitions

Workcell: A workcell is the complete environment around each robot. May include tools, machines and/or other robots.

Payload: The size and weight of the material each robotic arm can lift. A robot's total payload must also include the existing weight of the robots end effector or tooling

Teach Pendant: A handheld device used to manually control, program, and troubleshoot a robotic arm without the need for a full control terminal.

Parts of a Robot

Parts in an Industrial robotic arms are broken into five different categories: main controller, robotic arm, drive system, end of arm tooling, and sensors.

Main Controller: The brain of the robotic system. Used to control the motion of and programming of the robot as well as control various inputs and outputs and communicate with other elements in a work cell.

Robotic Arm: The positionable part of the the robot that is used to locate and position the end of arm tooling.

Drive System: The power or motors that are used to control the positioning of the robotic arm.

Parts of a Robot

Drive System: A robot's drive system is either electric, pneumatic, or hydraulic

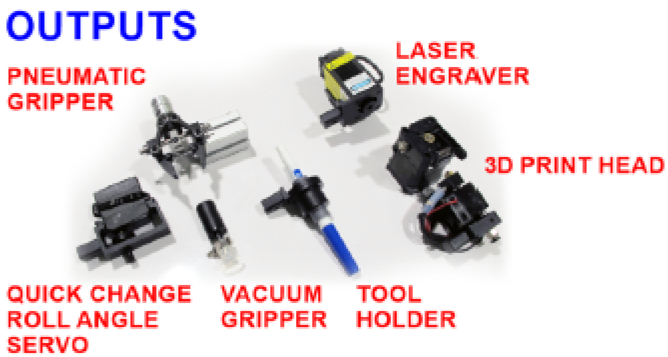
Electric Drive System: Used for high accuracy repeatability and speed. Used to control motors, servos, or stepper motors.

Pneumatic Drive System: Used in in smaller robots. Used to control rotary actuators or sliding joints. Typically used for high speed operations, and limited movements,

Hydraulic Drive Systems: Used for larger robots the require large amount of power. Linear movements is produced by hydraulic pistons while rotary is produced by rotary vanes.

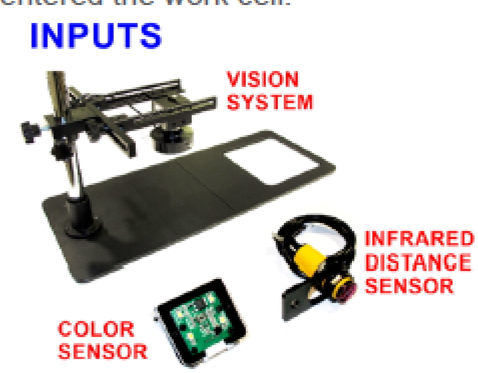
Parts of a Robot

End effector / End of Arm Tooling (EoAT): A robot's end effector is defined as the tooling added to the end of a robot's arm that allows it to perform specific operations. Examples: Spot Welders, Paint Sprayers, Grippers, Inspection Probes



Parts of a Robot

Sensors: Provide feedback as inputs to the robots controller about its environment. Sensors can be used to find objects, defereniate objects, keep robots from colliding into obstructions, other robots, or identify when unwanted obstacles have entered the work cell.



Resources

robotics. 2018. In Merriam-Webster.com.
Retrieved June 20, 2018, from https://www.merriam-webster.com/dictionary/robotics

Activity 1: Robot Axis & Movement

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

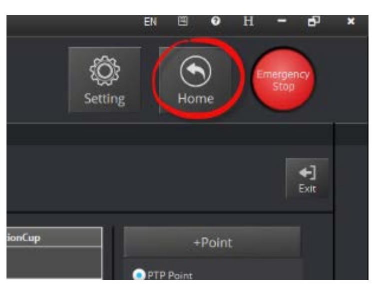
Caution: NEVER wire anything to the Dobot Magician while it has power on. ALWAYS turn it off before making connections or damage to the robot could occur.

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.
- Open DobotStudio software.
- Turn on the power to the Dobot.

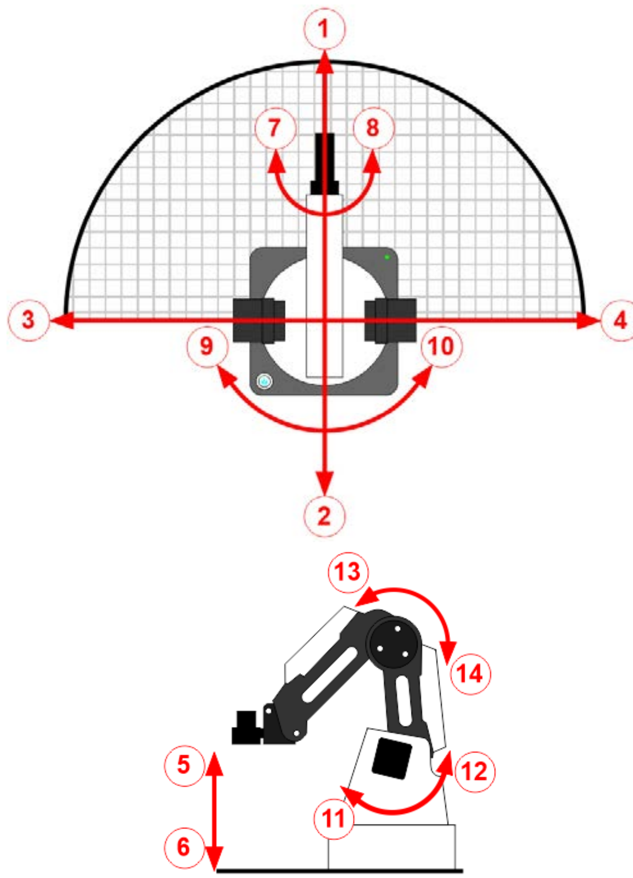
2. Open DobotStudio software and connect the robot in the software.

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 +/-.



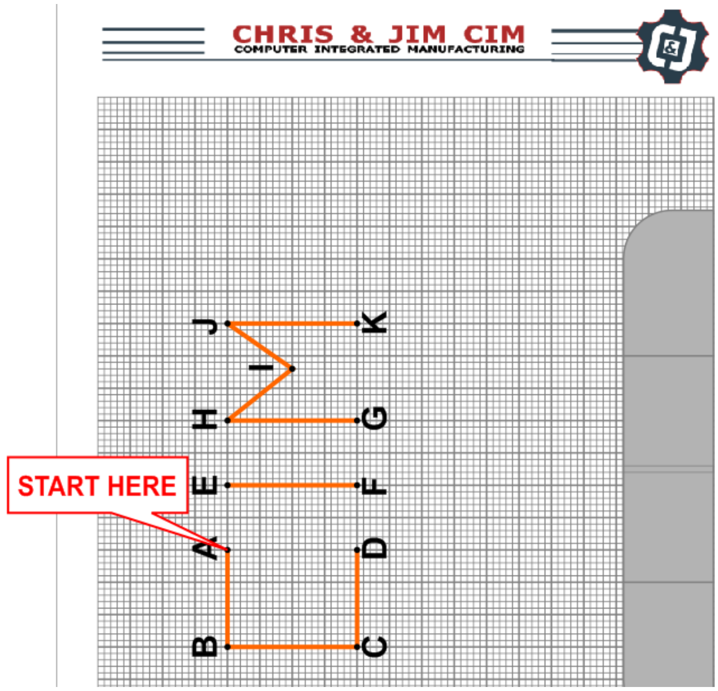
Using the information you documented on the previous diagram. Write down the correct axis/joint button in the first empty column, and a description of what it does in the second.

		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?*

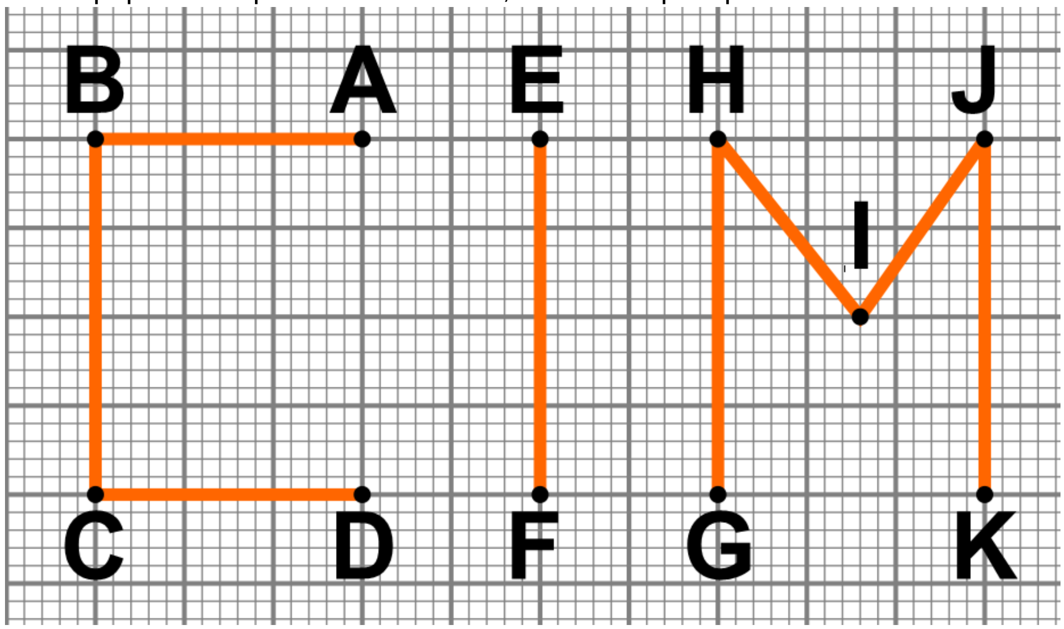
8. **MAIN OBJECTIVE:** Write the word “CIM” on the piece of paper as shown. Start at the point as shown in the diagram and move the robot from point to point to write the word using straight lines. Be sure to pick up the pen between letters and send the robot to a position away from the paper when finished.



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.

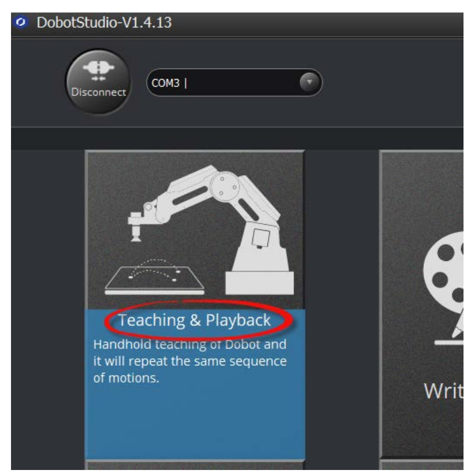


11. Line Segment lengths are as follows:

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.

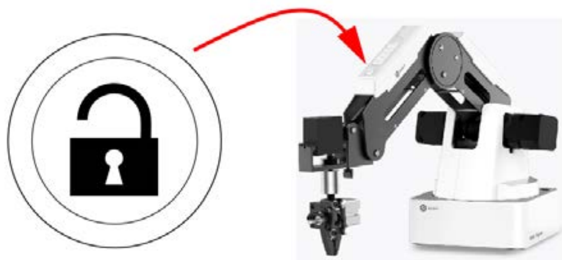


We will use this module to **RECORD** and **TEACH** the robot the points we want it to go to write the word CIM. **RECORDED** points are points found using the lock button on the robot's arm. By **TEACHING** points, we just type in the XYZ coordinates, and we do not have to move the robot around. This 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.

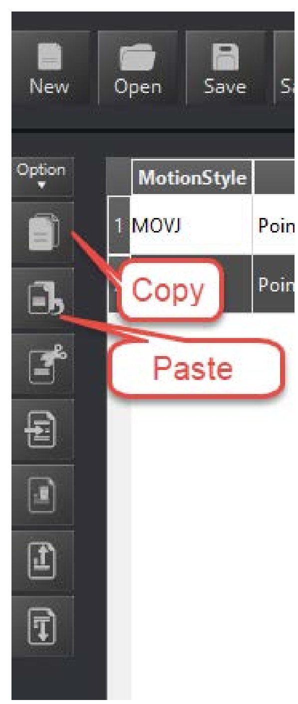


	MotionStyle	Name	X	Y	Z	R	PauseTime
1	MOVJ	Point A	255.31	34.26	-55.0	29.8444	0.0

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!

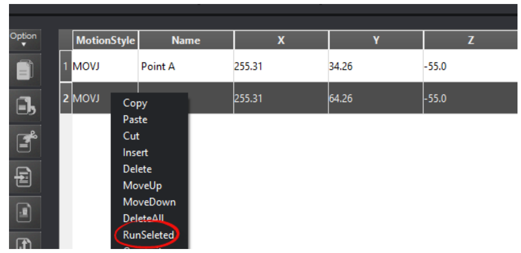


X = ____________

Y = ____________

Z = ____________

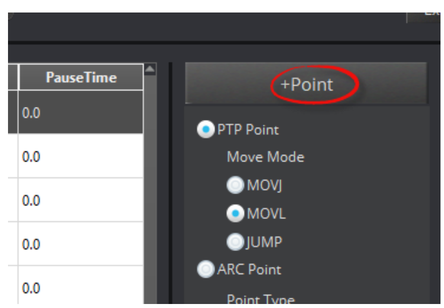
18. Right click on point B and select *RunSelected* and see if it moves where you want it to. Change the values for X and Y until it does.



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.

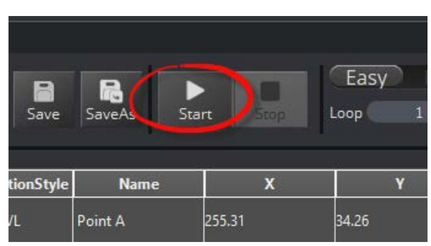
Name	**X**	**Y**	**Z**
Point A			
Point B			
Point C			
Point D			
Point E			
Point F			
Point G			
Point H			
Point I			
Point J			
Point K			

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.



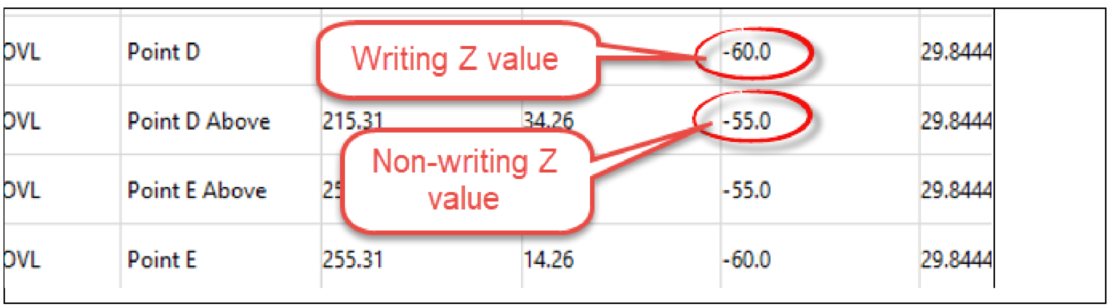
21. Press the start button and see if it runs through your complete program correctly.

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 and 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.



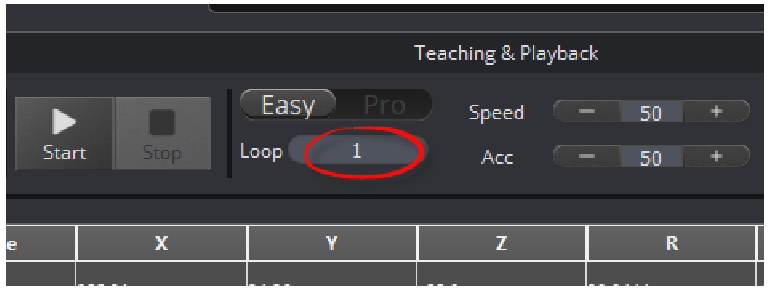
Now do the same for the move between points the letters I and M of CIM.

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.

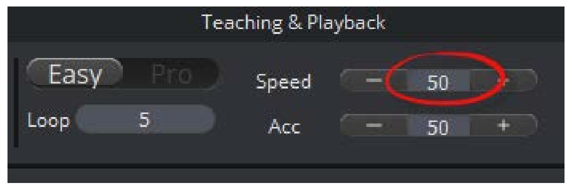
26. Using the *Loop* button, change it to 5 and watch your program **LOOP** five times when you hit the start button.



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.

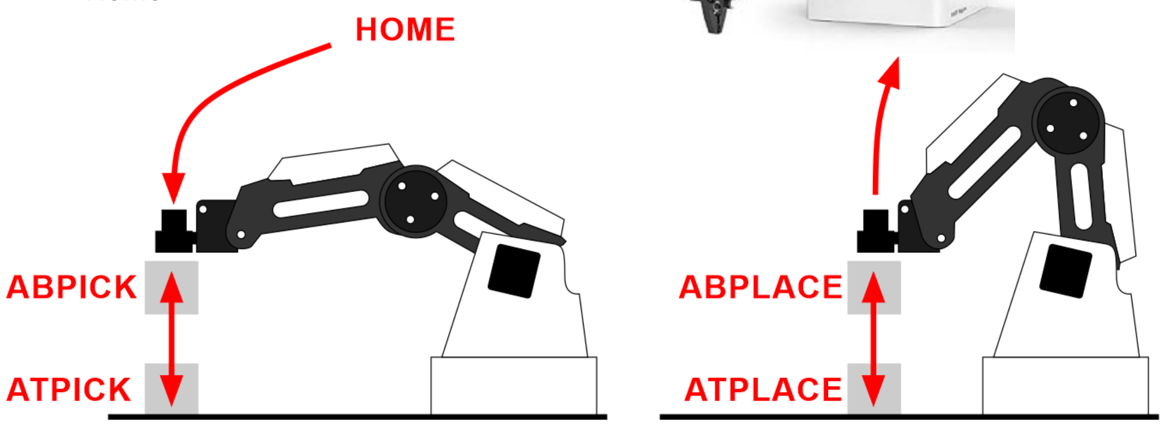
__________ 3. Teach the robot to write arcs.

Activity 2: Pick and Place

INTRODUCTION

Robotic arms are excellent for performing pick and place operations such as placing small electronic components on circuit boards, as well as large boxes on pallets. A pick and place operation will require at least 5 points:

- Home
- Above the pick point
- At the pick point
- Above the pick point
- Above the place point
- At the drop point
- Above the place point
- Home



As a rule, always go to a position above the pick or place point first so that the robot can accurately and repeatedly place the object straight down in a linear motion, with no friction or interference.

KEY CONCEPTS

- How does a robot perform a **pick and place** operation?
- What **end effector** or **end of arm tooling** works best?
- What are Pick and Place **conventions** in industry?
- How do I attach the **Mechanical Gripper** to the Dobot?
- How do I **record** positions with the Dobot?
- How do I easily edit a program in DobotStudio?

KEY VOCABULARY

- Relative positions
- Palletizing
- Pick and Place
- Home
- Linear movements
- Joint movements
- End effector
- End of Arm Tooling (EoAT)

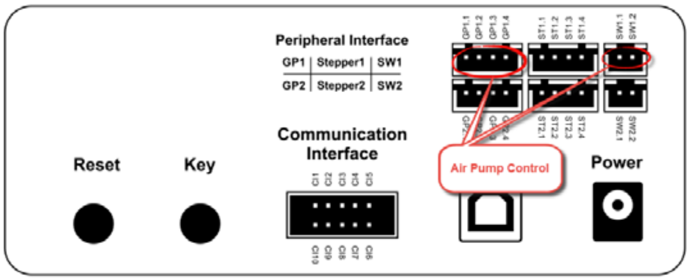
EQUIPMENT & SUPPLIES

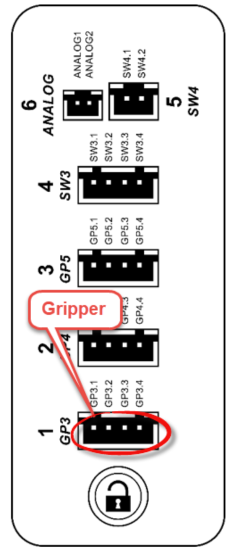
- Dobot Magician Dobot Field Diagram
- ¾ inch cylinders
- ¾ inch cubes
- Pneumatic Gripper
- DobotStudio software

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.

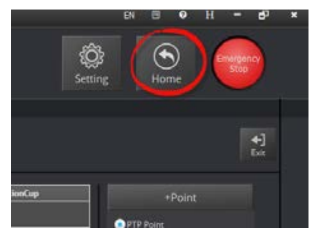
1. Attach the *Gripper* to the *rotational servo* and then attach it to the robot, and plug in the wires as shown below





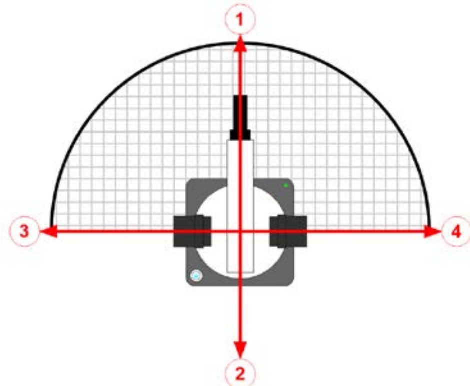
2. Open Dobot Studio software and connect the robot.

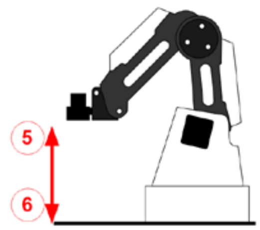
3. *Home* the robot making sure the robot's work envelope is clear.



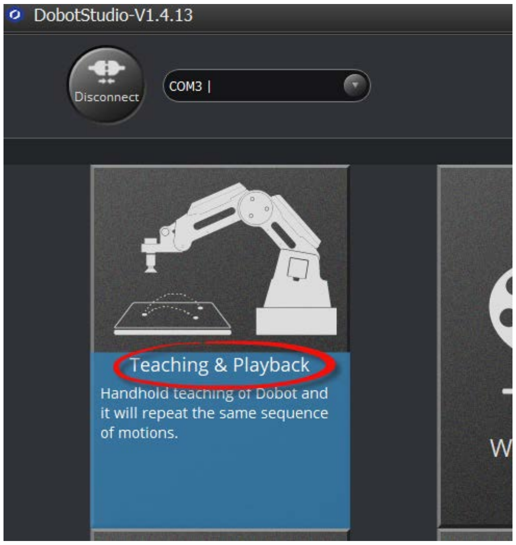
4. Be sure the *Gripper* is chosen as the accessory.

5. Open the *manual control panel* and move the robot around. In the space below, draw a diagram showing the X and Y axis on the robot. Be sure to label the arrows as +/-.





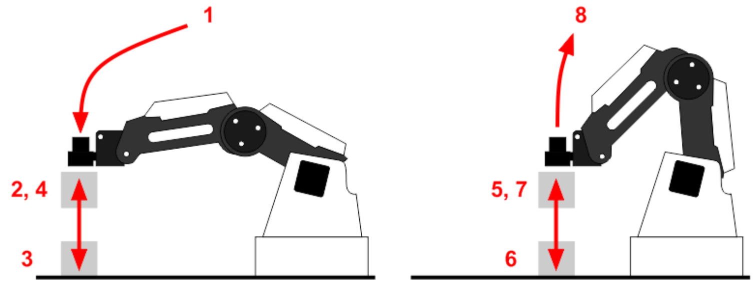
6. Now open the *Teach and Playback* module:



7. Place one of the ¾" wooden cylinders on one of the squares of the field diagram.

8. Use the *"Lock" button* on the arm to record all the positions necessary to do a pick and place operation in this order:
    - Home
    - Above Pick
    - At Pick

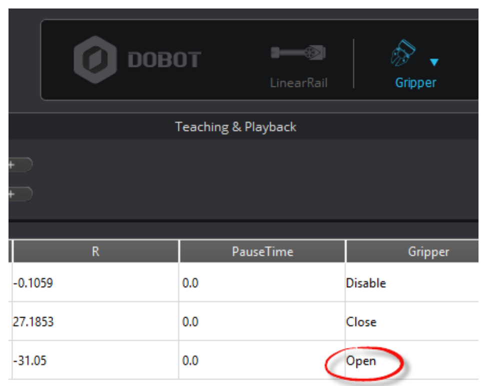
- Above Pick
- Above Place
- At Place
- Above Place
- Home



9. Name the positions in the *name column* of the program.

Be sure to name the positions something relevant so that others will be able to tell what the positions are. Example: A point named AbPick means the point above the place where it is picked up.

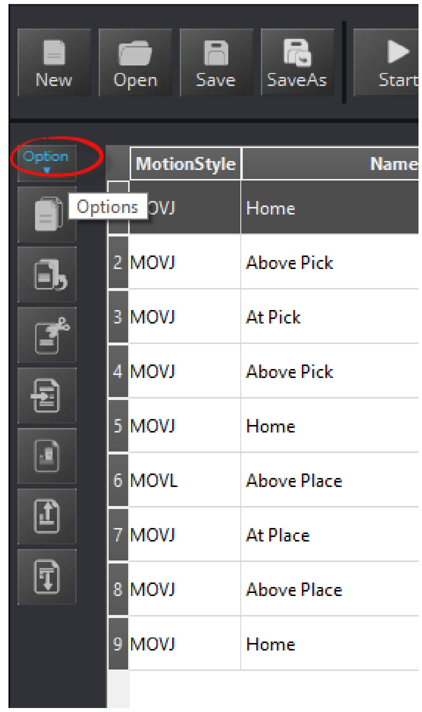
10. Be sure to open and close the gripper using the *gripper column* as shown.



11. Hit the "*Play*" button to run your program and see what happens. *Did it work the first time? If not, what did you have to change to make it work?*

12. Change the position type of step #5 (above place) in the first column to *Move Linear* (*MOVL*). *Run the program. What changed?*

13. Using the *options menu*, add another Home position between the Above Pick and the Above Place (steps 4 & 5)



HELPFUL TIPS

Use Copy, Move Up, Paste, or Move Down commands. that you used before in the options menu as shown.

14. Save your work.

CONCLUSION

1. *How can you get the suction to turn on in time to pick up the part, or get it to shut off in time to drop it off correctly? Explain below after you have tried it in the program.*

2. *What happens if you replace the ¾" cylinder with a ¾" wooden cube? Run it and see. Describe below what happens.*

GOING BEYOND

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

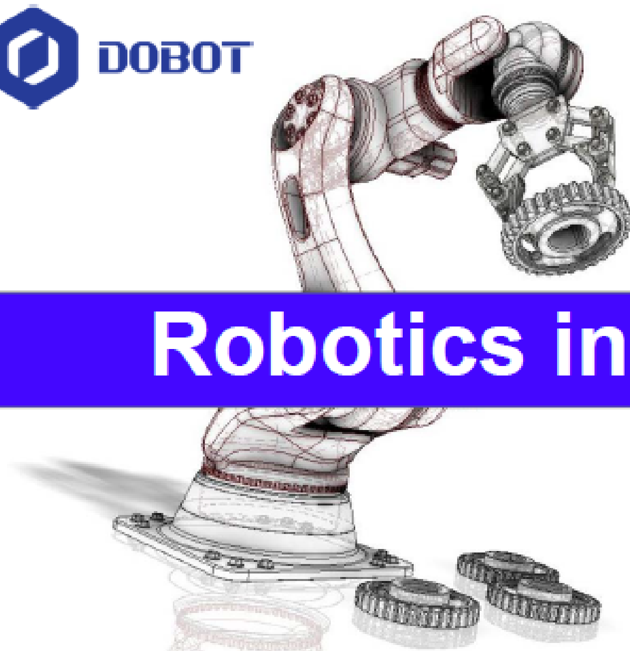
_________ 1. Have the robot reverse the process and put the cube back in its original place.

_________ 2. Make the process happen multiple times.

_________ 3. Adjust the speeds of each position to increase efficiency but not lose accuracy.

Presentation: Robotics in Industry – Applications

DOBOT



Applications

Robotics in Industry

www.ChrisandJimCIM.com

Robots Vs Humans

There is a lot to consider when deciding if a human task should be replaced with automation or robotics:

-Several of these reasons center around reducing cost, increasing productivity, and ethics.

Reasons of using Robots in Industry:

-Mass Production and Repeatability
-High Dependability
-Ease of Upgrade (New Skills)
-Speed and Accuracy
-High Payload Capability
-No Cognitive Bias
-Ability to Retain Complex sets of Instructions

-Reduced Labor Costs
-Hazardous Tasks
-Expendable
-Complex Operations
-Predictability
-Compliance to Instructions

Robots Applications and Skills

Common Robots Applications:

-Welding Examples

-MIG, TIG, Arc Welding *-Spot Welding* *-Plasma Cutting*

-Resistance Welding

-Material Handling Examples

-Machine Tending *-Dispensing* *-Palletizing*

-Packaging *-Pick and Place* *-Part Transfer*

-Material Removal Examples

-Cutting *-Drilling* *-Milling*

-Routing *-Waterjet Cutting* *Laser Cutting*

-Grinding/Deburring/Sanding/Polishing

Robots Applications and Skills

Common Robots Applications:

-Coating Examples

-Painting *-Powder Coating* *-Coating*

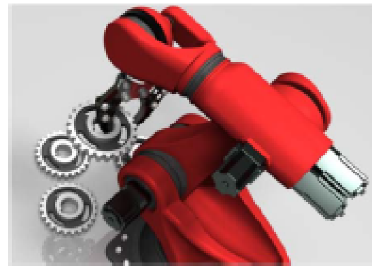
-Shell Coating *-Degreasing*

-Other Examples

-Vision and Inspection *-Sealing*

Robots Applications and Skills

Pick and Place Robots



Pick and Place is defined as retrieving parts from one location and consistently placing them in a new location. This process can be extremely fast and very repeatable. Pick and place robots are used to automate and speed up repetitive operations which in turn can increase production rates and lower product costs.

Examples: Installing electrical components, loading and unloading machines, retrieving items from storage and placing them in packaging, assembling parts

Robots Applications and Skills

Pick and Place EoAT

Pick and Place robots can be outfitted with a wide variety of End of Arm Tooling (EoAT). This flexibility greatly increases the range of applications.

Robots best suited for Pick and Place: SCARA, Delta, Cartesian, Jointed/Articulated Arm

Examples: Mechanical Grippers, Pneumatic Suction Cups, Vacuum Grippers, Electromagnetics, Soft Touch Pneumatic Grippers, Bag Grippers

Robots Applications and Skills

Palletizing Robots

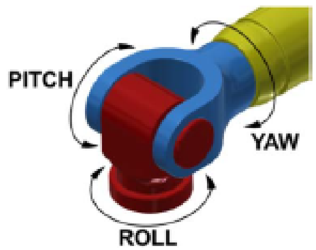
Palletizing robots are used to automate the process of loading and unloading parts, containers, boxes or like items onto and off of pallets for storage and shipping.

Palletizing robots typically have a large range of motion and heavy payload capability. They can often be seen in the shipping or receiving department of most factories.

Robots Applications and Skills

Palletizing Robots - Gripper Roll Angle

Due to the fact that most packaging containers are square, palletizing robots need to have the ability to adjust the EoAT's roll angle. Adjusting the roll angle is used to line up and nest the packages onto the pallet to minimize lost space and increase stability when stacking items onto a pallet.



Resources

All photos, graphics, images & icons included in this presentation are the intellectual property of ChrisandJimCIM.com.

Activity 3: Using Jumps and Loops

INTRODUCTION

A pick and place style of moving objects around are staples of industrial robots. Another reason to use robots in industry and automation is because of danger to humans. Robots can work in adverse environments that are dangerous to humans; especially when dealing with chemicals and other toxic substances.

Sometimes the best way to pick up an object is with a suction cup or vacuum gripper. This works especially well with very small objects and provides a less expensive alternative to a mechanical gripper.

In this activity, you will perform an anodizing operation (which can use harmful chemicals) with a robot arm using the air pump kit and a vacuum gripper.

Do not let go of the object in the tanks… Just wait for the 2 second dip to complete and move on.

***Dip Tank Set Up** using 3D printed dip tanks and a Dobot field diagram. In this diagram four tanks are used.*

Remember: We always go to a position above the pick or place point first so that the robot places the object straight down, with no friction or interference. This will increase accuracy!

KEY VOCABULARY

- TCP
- Loop
- Touch up
- Teach
- Suction
- Vacuum
- Linear movement
- Joint movement

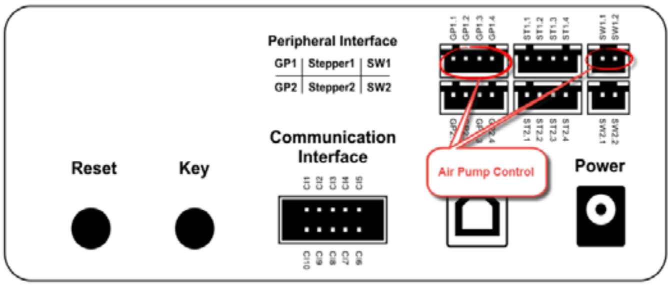
EQUIPMENT & SUPPLIES

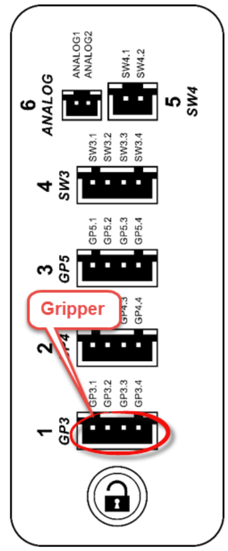
- Dobot Magician
- Dobot Dipping Field Diagram
- ¾ inch wooden cylinders
- End of arm tooling (EoAT)
- Suction Cup Gripper
- DobotStudio software
- 4 simulated dip tanks *(1" PVC Caps or small plastic cups work well)*

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.

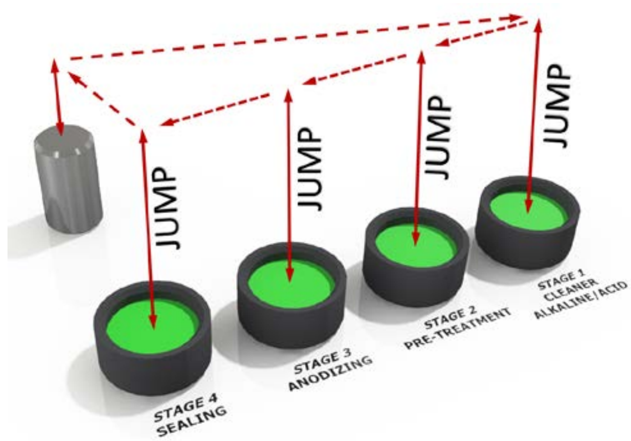
1. Attach the *Suction Cup* to the *rotational servo* and then attach it to the robot, and plug in the wires as shown below.

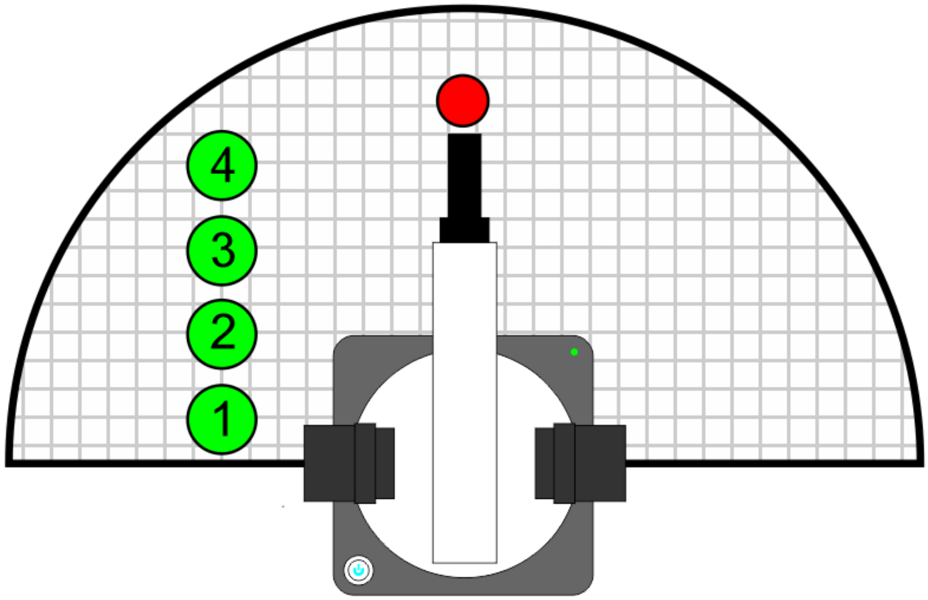




1. Open Dobot Studio software, connect and home the robot, and be sure the *Suction Cup* is chosen as the **END OF ARM TOOLING (EoAT)**

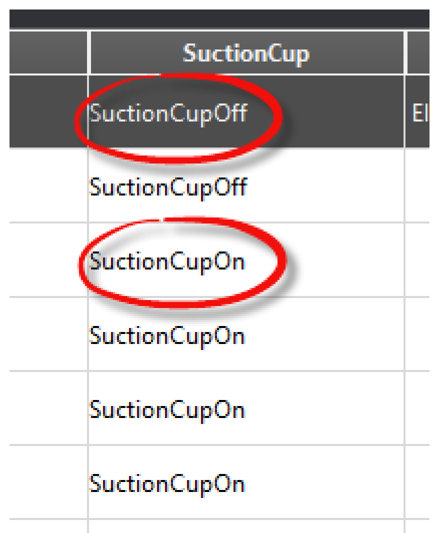
2. Now open the *Teach and Playback* module in DobotStudio and write a program to perform the following actions:
    a. Go home
    b. Pick up the cylinder from the pallet
    c. Dip it in Tank 1 for 2 seconds
    d. Move the object and dip it in Tank 2 for 2 seconds
    e. Move the object and dip it in Tank 3 for 2 seconds
    f. Move the object and dip it in Tank 4 for 2 seconds
    g. Move the part back to the pallet.
    h. Go home





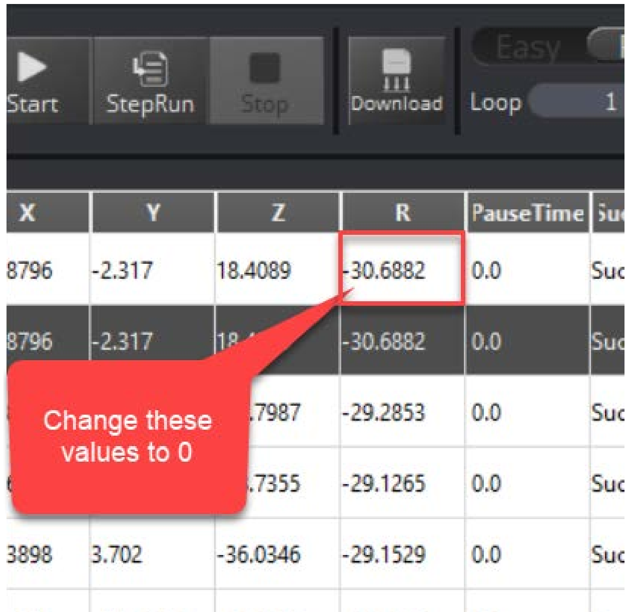
3. Be sure to turn on/off the *Suction Cup* when necessary.

4. Hit the *Play* button to run your program and see what happens. *Did it work the first time? If not, what did you have to change to make it work?*



	SuctionCup	
	SuctionCupOff	El
	SuctionCupOff	
	SuctionCupOn	
	SuctionCupOn	
	SuctionCupOn	
	SuctionCupOn	

5. When recording points using the *lock button*, it is not always very accurate. When you look at all the Z values of all the above tank positions, they are probably very different.



We can make them all the same by clicking on the values and typing in a value that works well; this is called **TEACHING**. When fixing points like this it is also called **TOUCHING UP** points.

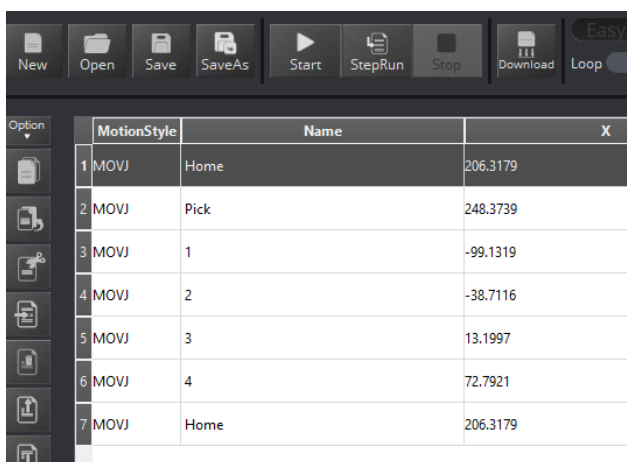
Go and **TOUCH UP** all the z values to make the dipping operation happen at the same heights above the tank, and in the tank and have your instructor check it.

You can even use this method to touch up the x and y values of the tanks to make sure they are in a straight line.

6. How many lines of code did it take to write the program using what you have learned before? How many points did you have to teach it?

7. Now we are going to use the **JUMP** command to make the program even easier, and much more accurate. Open a new program.

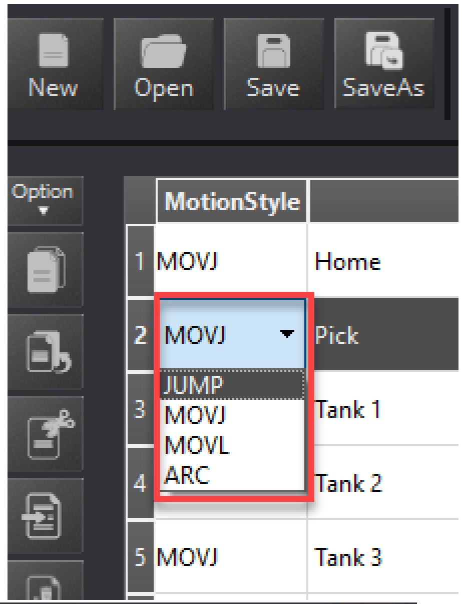
8. This time, only record the following points: Home, Pick, Tank 1, Tank 2, Tank 3, and Tank 4. Do not record the above points.



9. Now change the MotionStyle of the Pick, Tank 1, Tank 2, Tank 3, and Tank 4 to *JUMP*. Double click on the *MotionStyle* box for each point and change it from *MOVJ* to *JUMP*

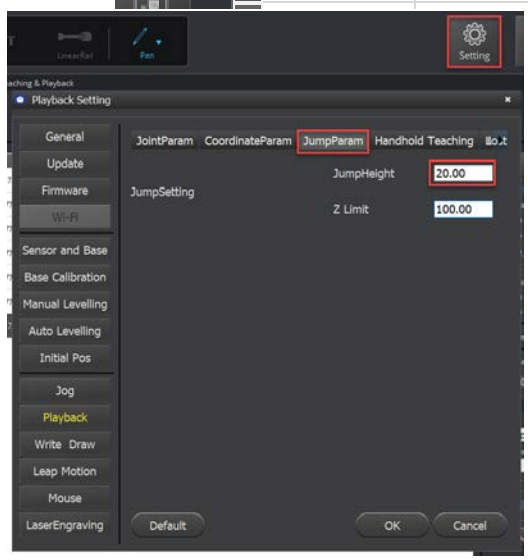
Now play the program.

What does this change do to the program?



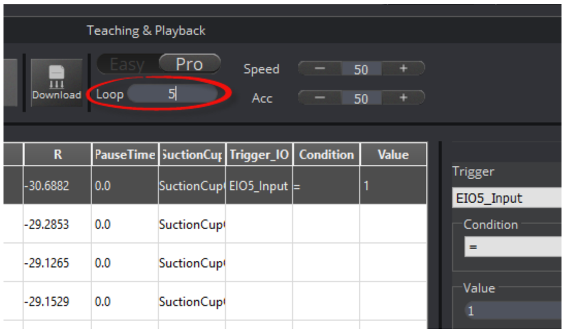
10. If you ever want to change the height in Z that the *JUMP* actually jumps to, open the *Settings*, and on the *JumpParam* tab change the *JumpHeight* to whatever you need it to be to clear the tank.

Compare the first dipping program to the second one with JUMPS and explain how it is more efficient.



11. Now let's make the robot repeat the operation five times. It's easy. We use a tool called **LOOP** to make something happen multiple times so that our program is shorter and more efficient.

12. To make your program **LOOP** multiple times, just add the number of times you want it to repeat.



13. Be sure to save your work when done.

CONCLUSION

1. *Describe a MOVL move using the Dobot.*

2. *Describe a MOVJ move when using a Dobot.*

3. *What makes a Jump command more efficient to code than a MOVJ or MOVL?*

4. *What kind of manufacturing process is dipping? Explain your answer.*

5. *What is anodizing? Explain how it works and why we do it.*

GOING BEYOND

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

__________ 1. Take away the first tank and change the program to fix the operation using the software.

__________ 2. Add another tank and change the program to fix the operation using the software.

__________ 3. Raise the tanks using a block of wood provided by your instructor and fix the operation using the software. *What is the most efficient way to do this?*

Activity 4: Using Digital Inputs

INTRODUCTION

Robotic arms need to be able to communicate with an operator so that you can tell it when to begin or end an operation. We can do this very easily with an input connected to the arm. This input can be something as simple as digital on/off switch

In this activity, you will perform a pick and place with a robot arm using the air pump kit and a vacuum gripper or mechanical gripper. You will make the robot wait for an input on a switch before it starts, and eventually you will make the robot repeat this five times. Here is what you want your robot to do:

- Wait for the operator to hit the start switch
- Go home
- Pick up the object
- Place the object in another spot
- Return home
- Operator moves the part back to the start
- Repeat

Suction cup gripper attached to the rotational servo.

HELPFUL TIPS

Remember: *We always go to a position above the pick or place point first so that the robot places the object straight down, with no friction or interference. This will increase accuracy!*

KEY VOCABULARY

- TCP
- Loop
- Pull Down Resistor
- Normally Open
- Suction
- Vacuum
- Digital
- Normally Closed

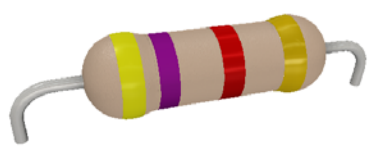
EQUIPMENT & SUPPLIES

- Dobot Magician
- Dobot Field Diagram
- ¾ inch wooden cylinders
- Servo extension cables
- Electrical tape
- Suction cup gripper
- Suction Cup or Mechanical Gripper
- DobotStudio software
- Digital Switch
- Jumper wire
- 3 prong male header pin
- Resistor 4.7KΩ to 15KΩ

PROCEDURE

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

1. Attach the *Suction Cup* or *Mechanical Gripper* as done in previous activities to the *rotational servo* and then attach it to the robot and plug in the wires as shown below.
2. Add the switch as an input. *Be sure to turn off power to the Dobot before continuing!*
3. Install a **PULL DOWN RESISTOR** on the ground side of the servo extension cable. The pull-down resistor will insure a well-defined logical level in our logic circuit. This resistor will help eliminate possible float values and will pull the input pin to a logical low state in all conditions. The pull-down resistor can have any value from 4.7KΩ to 15KΩ. The larger the resistance, the slower the input pins response will be to voltage in milliseconds.
4. ***One way to do this is shown below. Be sure to complete this portion of the activity the way that your instructor taught you.***



4.7k Ω - OUTPUT SIDE

YELLOW	VIOLET	RED	GOLD
4	7	X100	5%

Parts List

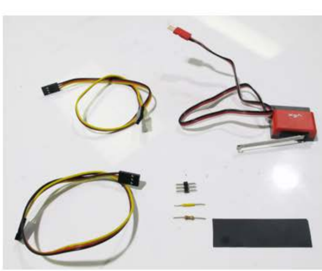
2 Servo Extension Cables
1 Male Header Pins - 3 Prong
1 Short Jumper Wire
1 Resistor 4.7kΩ to 15kΩ
1 Digital Switch
Electrical Tape or Heat Shrink

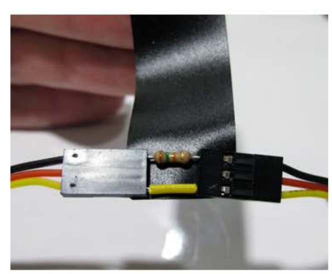
1. Install Resistor & Jumper Wire

The Resistor needs to be installed on the ground side to work as a pull down resistor.

2. Secure the Components.

Wrap the resistor and jumper wire with electrical tap or heat shrink to ensure they will not come apart





3. Ensure Connection

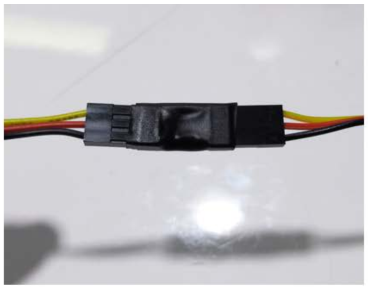
Lightly tug on the assembly to ensure the connection is stable

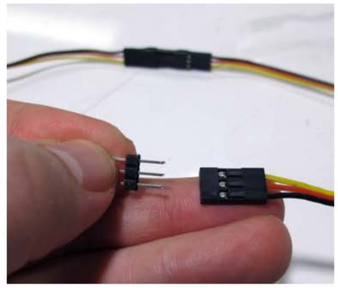
4. Install Male Header Pin

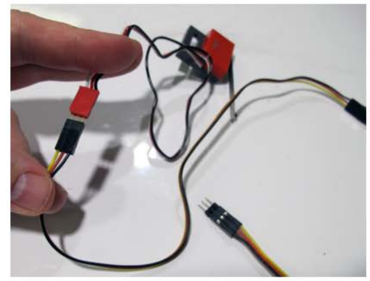
Install a 3 prong male header pin on one end of the servo extension cable, This end will go into the bread board.

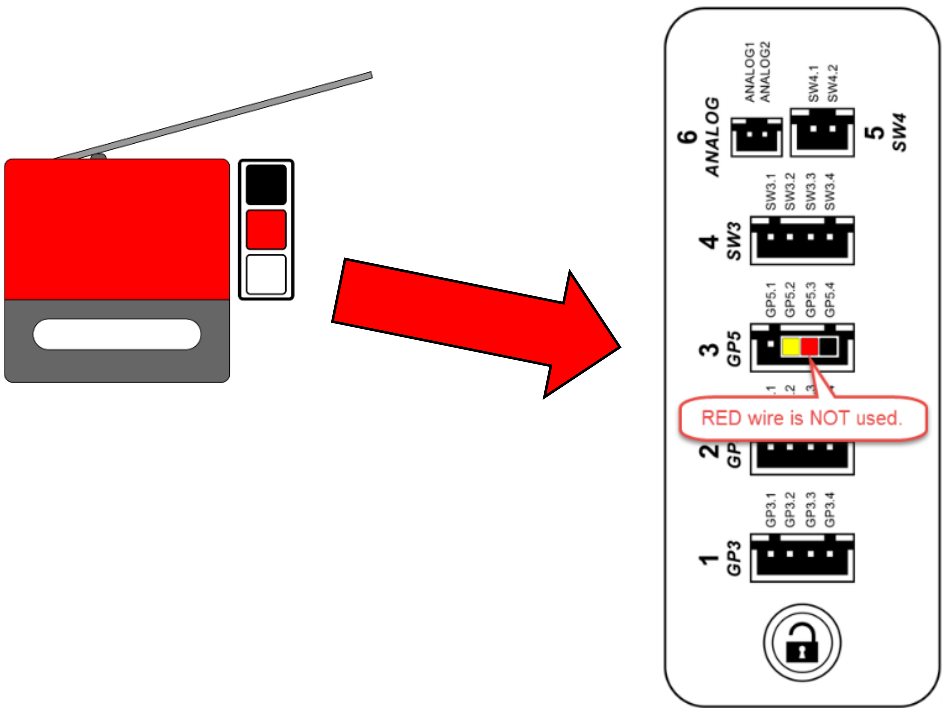
5. Install Digital Switch

Install a digital switch to the opposite end of the servo extension cable.









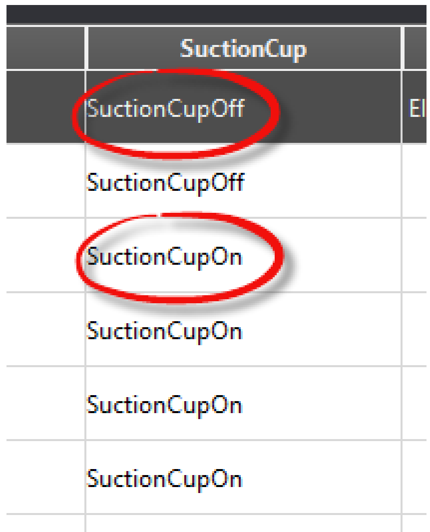
HELPFUL TIPS

Use the wire you made above to attach the switch to GP5 as shown in the diagram above. Always be sure the black wire on the extension cable matches the black wire on the switch.

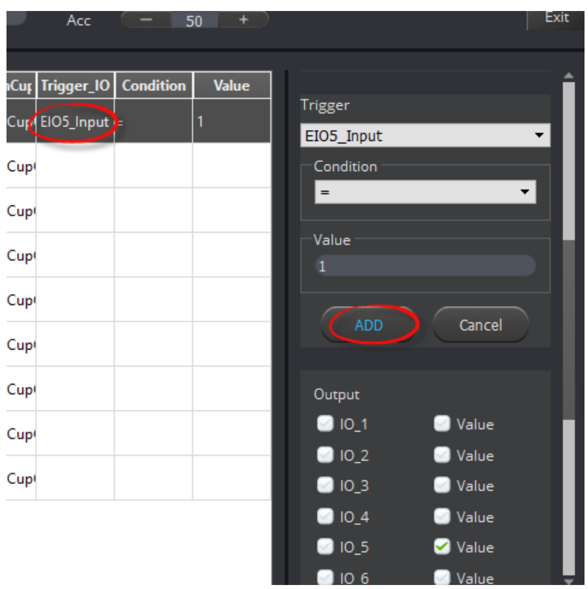
5. Open Dobot Studio software, connect and home the robot, and be sure the *Suction Cup* is chosen

6. Now open the Teach *and Playback* module and perform a pick and place with a wooden cylinder as you did in a previous activity. The only difference is that this time you will use the Suction Cup to pick and place the object. Be sure to use "*above*" positions. Save your program when finished. You may even be able to use a program you have already written and just touch up the points.
Be sure to have your instructor check when completed.

7. Be sure to turn on/off the suction when necessary



8. Be sure to add EIO5 as an Input on the first line of the program. This will ensure that when you hit the switch (Turn it on) the robot will start the rest of the program.



HELPFUL TIPS *You must be in Pro Mode to do this!*

9. Hit the *Play* button to run your program and see what happens.

10. Did it work the first time? If not, what did you have to change to make it work?

11. Now let's make the robot do this five times, as you did in the last activity.
    Be sure to have your instructor check when completed.

12. Be sure to save your work when done.

CONCLUSION

1. *What is the purpose of the resistor in the wire that you made at the beginning of the procedure?*

2. *What might happen if you did not use this resistor?*

3. *What does it mean that the switch is DIGITAL?*

4. *What type of operation could this be simulating?*

5. *Is the switch you used Normally open, or Normally closed? How do you know?*

GOING BEYOND

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

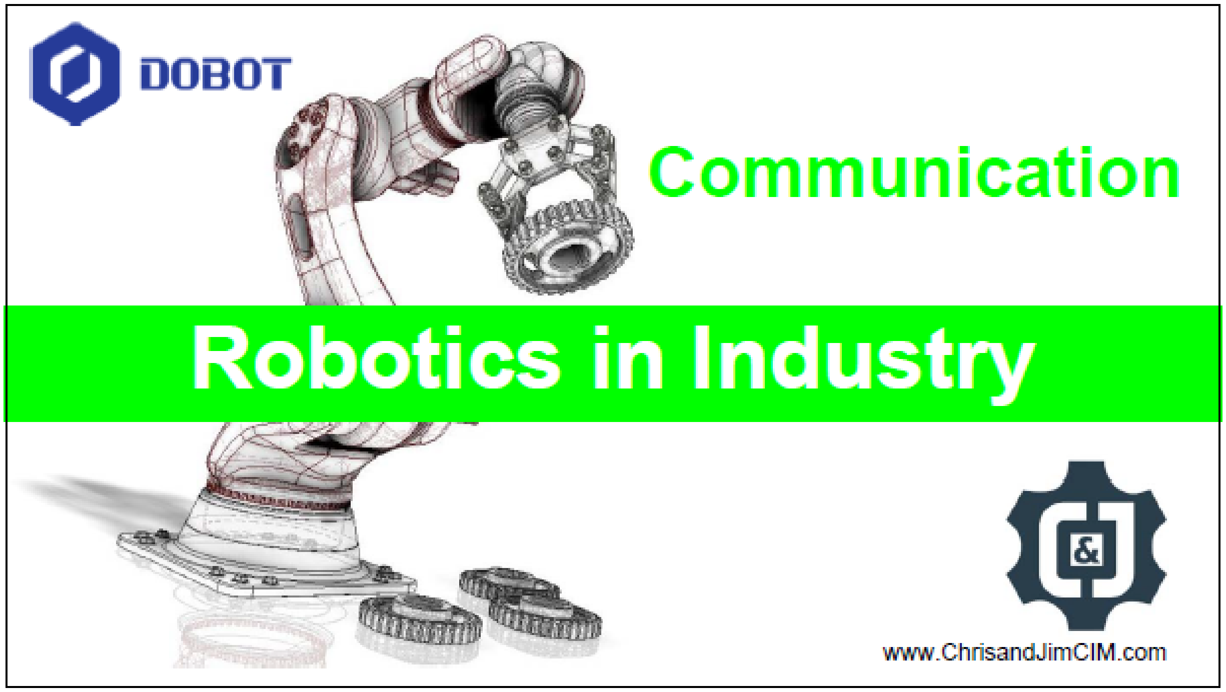
_________ 1. Look in the inputs and outputs manual and find another open input you might be able to use. Check with your instructor to be sure you choose an appropriate one, and then make the robot move the object to another predefined position when you hit that switch.

_________ 2. Can you use something else as an input to the robot to make it do something? Check with your instructor and try something else.

_________ 3. Wire a microcontroller to be an input for the robot.

HELPFUL TIPS Ask your instructor about what to use for this activity.

Presentation 3: Robotics in Industry - Communication



Robots Communication

Inputs and Outputs:

-Industrial robots are designed to send and receive a wide variety of signals and instructions.

-These signals can be as simple as informing the robot when a task is complete or as complex as helping the robot find a particular part, identify its orientation, and even help it make intelligent decisions such as should the robot retrieve the part or choose a different part.

-These signals can come from a wide variety of internal and external sources

Robots Communication

Handshaking:

-When communicating with industrial robots, one of the biggest concerns is how to safely communicate when different voltages and currents can be present and could result in signals that could damage equipment.

-Handshaking is defined as safe communication between two or more, like or unlike, pieces of technology.

-This is done with special electronics that have no physical wiring or connections.

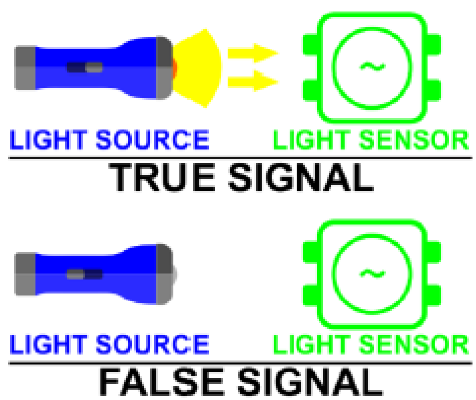
Robots Communication

Handshaking:

-Handshaking signals (questions and answers) need to be broken down into simple yes or no, true/false questions.

-The example to the right shows a signal being sent with a light and a sensor

-No physical connection is needed



Robots Communication

Handshaking:

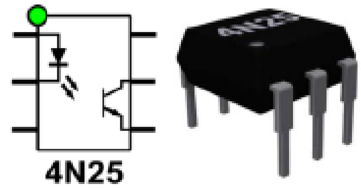
-Electrical Components Examples

-Solid State Relay or Optocoupler/Optical Isolator

(Infrared LED & Photo Sensor)

-Mechanical Relay or Electromagnetic Relay

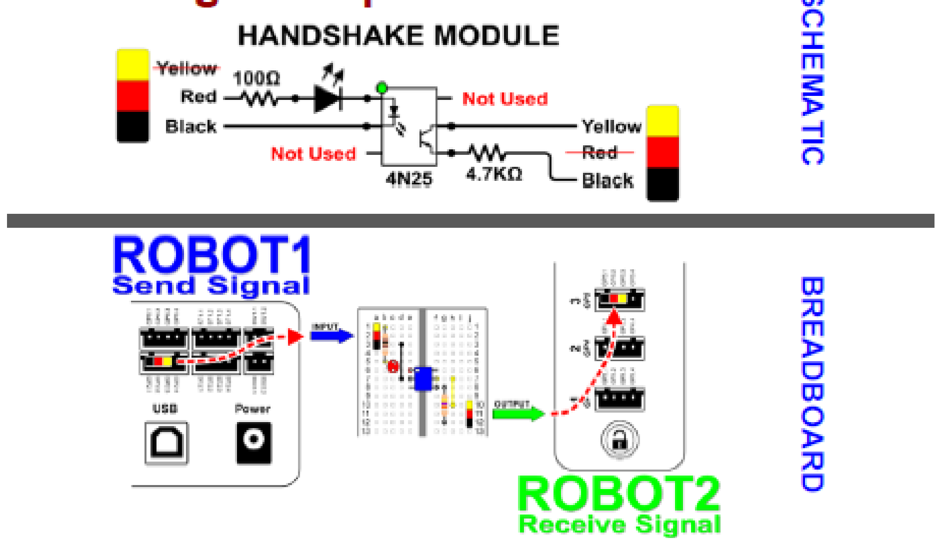
(Electro Magnet & Mechanical Switch)



Solid State Relay

Mechanical Relay

Handshaking Example



Robots Communication

Sensors:

-Sensors are inputs that provide feedback and bring in a variety of data into the robot.

-Sensors can be broken up into two main categories; passive and active

-Active Sensors

-Require an external power source to operate

-Passive Sensors

-Respond and detect inputs from the physical environment without external power

Robots Communication

Sensors:

-Sensors are further divided into several different classifications and types

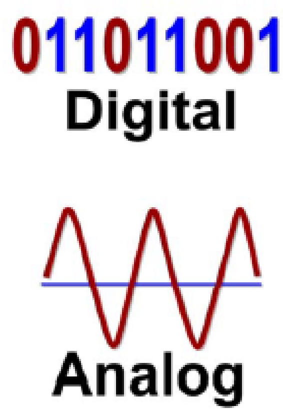
-Means of Detection - *Electrical, Chemical, Light, Sound, Motion...*

-How they Operate - *Photoelectric, Thermoelectric, Electrochemical, Electromagnetic...*

-Analog or Digital

-Analog Signals contain a range value

-Digital Signals are on or off, with no in between values



Robots Communication

IR Sensor

Sensors:

-Sensor Examples

-Temperature *(Measures Change in Temperature)*

-Proximity *(Non-Contact Presence of and Object)*

-Accelerometer *(Measures Acceleration)*

-Infrared (IR) *(Light Based Sensor used to Detect Objects or Proximity)* -Ultrasonic (Non-Contact used to Measure Distance or Velocity)

-Inductive *(Non-Contact used to Detect the presence of Metal)*

-Light or PhotoCell *(Detect varying amounts of Light)*

-Phototransistor *(Detects the presence of Intense Light)*

Robots Communication

Color Sensor

Sensors:

-Sensor Examples

-Potentiometer (pots) *(Used for Rotational Positioning)*

-Limit Switch or Touch *(Contact Sensor used to Detect Proximity)*

-Color *(Detects Color or Reflected Color.)*

-Encoder - Incremental or Absolute *(Used for Rotational Positioning)*

-Gyroscope (Used to Detect Rotation on each Axis)

Robots Communication

Sensors:

-Vision System - The eyes of an industrial robot

-Locate parts to be picked up

-Inspect parts for quality control

-Determine orientation

-Detect the presence or absence of an object

Vision System

Robots Communication

Outputs:

-Robots can be used to send signals to a wide variety devices.

-Robots send digital output signals through handshaking or direct connections and can be connected directly to machines and equipment that they interact with.

-Industrial robots can also communicate digitally with a Programmable Logic Controller (PLC) or microcontroller and have them control various outputs.

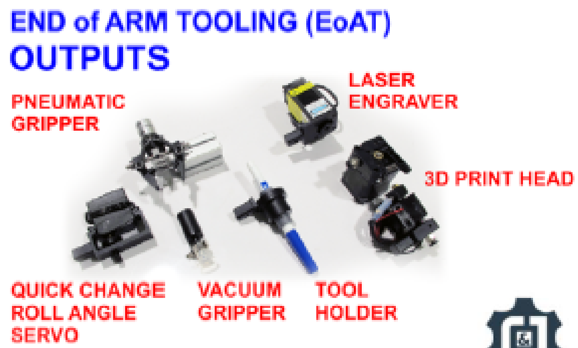
Robots Communication

Outputs:

-Industrial robot can also control various outputs that are part of their End of Arm Tooling (EoAT)

Turn on and Off

-Pneumatic Air for a Vacuum Suction Cup
-Pneumatic Air for a Pneumatic Gripper
-Feed and Heat for a Prototyping Head
-Laser or Plasma Cutter
-Feed for a MIG Welding Torch
-Closing and Power for a Spot Welder



Resources

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Activity 5: Palletizing & Roll Angles

INTRODUCTION

Have you ever wondered why most consumer goods are delivered to your doorstep in rectangular boxes? Think about the shape of the truck they were delivered in. Or the shape of the boxcar or shipping container that they left the factory in. Most consumer goods are moved around on pallets that are rectangular as well.

In this activity you will learn how to palletize rectangular containers. Think about it… every time you move a rectangle from one point to another, there is a good chance that the edges will not line up. In this activity, you will learn how to calculate the amount you need to turn the boxes **(ROLL ANGLE)** to place them on a pallet properly. You will also learn how to make a robot perform the process called **PALLETIZATION**.

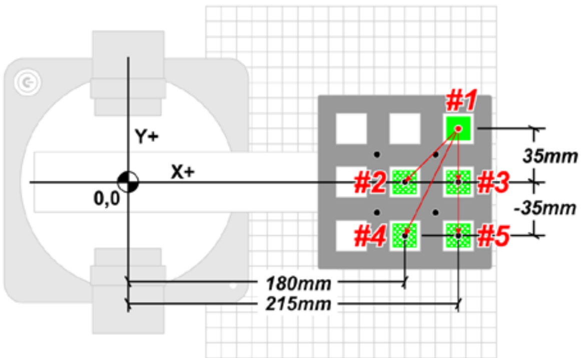
KEY VOCABULARY

- Pallet
- Roll Angle
- Palletization
- Pitch
- Yaw

EQUIPMENT & SUPPLIES

- Robot Magician
- Dobot Field Diagram
- Four or more ¾" cubes
- Pneumatic Gripper
- Jumper wire
- Suction Cup Gripper
- DobotStudio software
- Input switch
- 4.7 kΩ Resistor
- 2 Servo extension cables
- Electrical tape

PROCEDURE



In this activity, you are going to make the Dobot complete the following task:

a. Human places a cube at the START position.
b. When you hit the input switch, the robot moves the block to position #5.
c. Place another cube at START.
d. When you hit the VEX switch, robot moves the block to position #3.

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. Be sure to ask your instructor if you have any questions.

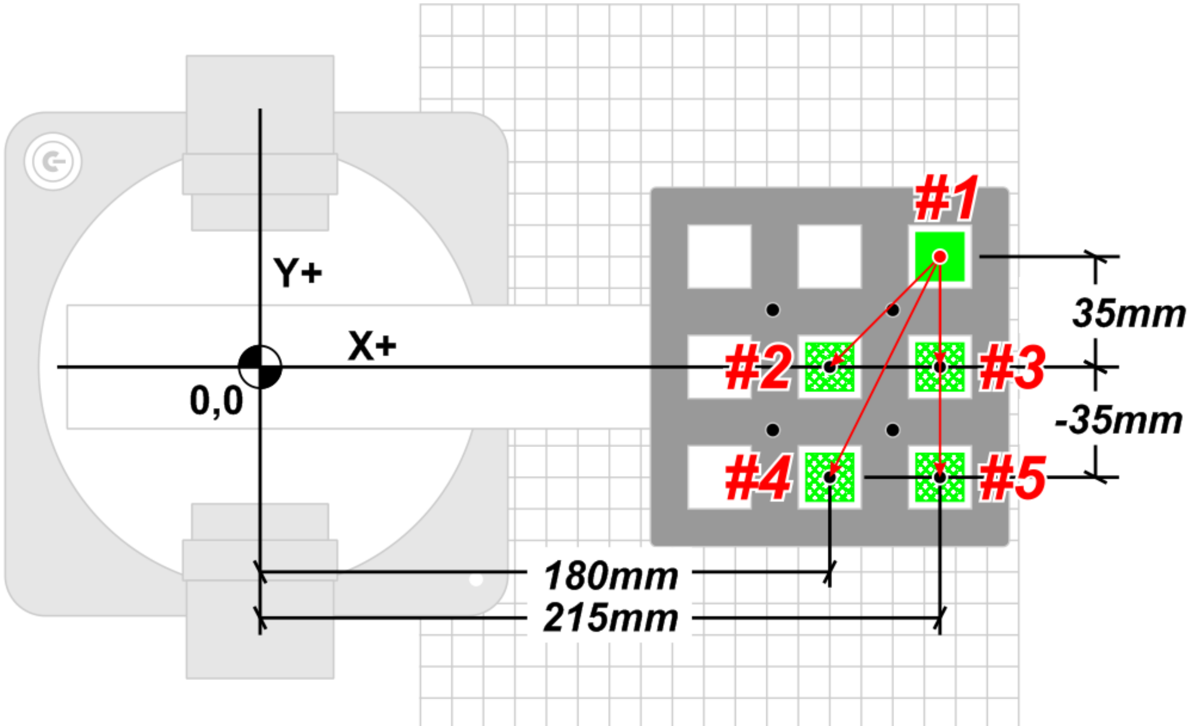
1. Wire the limit switch as done in previous activities and set up the robot and field diagram as shown.

2. Using teach, record, and the *options* menu in the teaching *and playback* module of DobotStudio make the robot place the two parts on the pallet .

3. What is wrong with the placement of the objects? Why is this so?

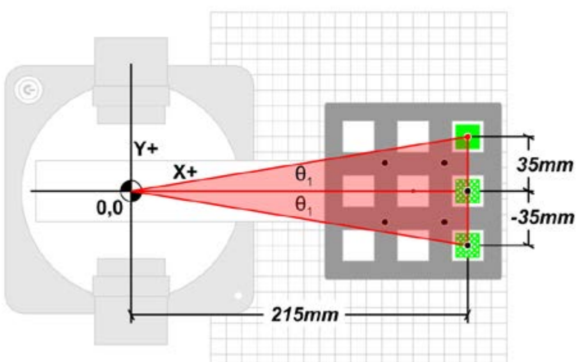
4. The software will calculate the roll angle for you relative to the first recorded position. In the following steps we are going to use math to calculate how the software derived these positions. After a demonstration by your teacher on how to do this, go ahead and calculate

Move the blocks from the common unload position (Position #1), to the finished pallet positions (Positions #2, 3, 4 & 5) as shown in the diagram below.
Manually replace the block in Position #1 for each pallet position.



5. In the space provided below the diagrams, calculate the correct roll angle for positions 1 & 5 relative to the X axis. Show your work even though you are using a calculator.

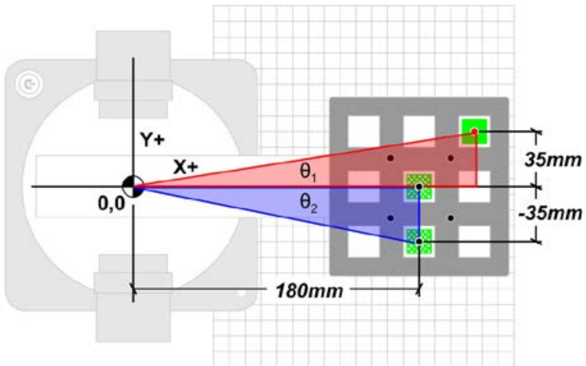
Note that: **Tan = Opp/Adj and = $\mathbf{Tan^{-1}}$(Opp/Adj)**



$$\theta_1° = \tan^{-1}(\text{Opp/Adj})$$

Calculation:

6. *In the space provided, calculate the correct roll angle for position 4. Show your work even though you are using a calculator.*

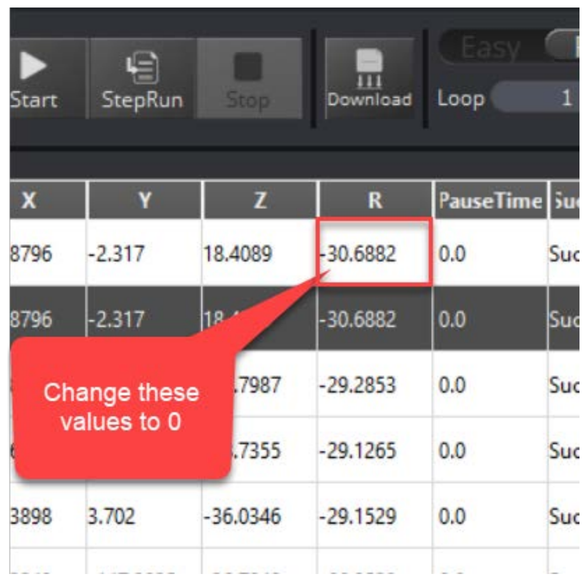


$$\theta_1° = \tan^{-1}(\text{Opp/Adj})$$

Calculation:

7. *In the space provided above, calculate the correct roll angle for position 4. Show your work even though you are using a calculator.*

8. In DobotStudio, the angle can be remembered and held from an original position. To do this we can have the software calculate the roll angle by changing the value in the R column for all the positions after the first one to zero "0".



CONCLUSION

1. *Pick another position off of the pallet, sketch the diagram in your notebook or on the field diagram and calculate the roll angle if the robot were to move a part there from position #1. be sure to show your work.*

2. *If you stacked another layer on top of the layer that is already on the pallet, would the roll angles change? Why or why not? Justify your answer.*

3. *If you swapped to the mechanical gripper, and touched up the points, would the roll angles still be correct? Why or why not? Justify your answer.*

4. *What is an advantage to a vacuum or suction gripper, when palletizing, over a mechanical gripper? Justify your answer.*

GOING BEYOND

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

__________ 1. Change the gripper to the mechanical gripper and try to recreate this.

__________ 2. Stack another set of blocks on top of the the first set.

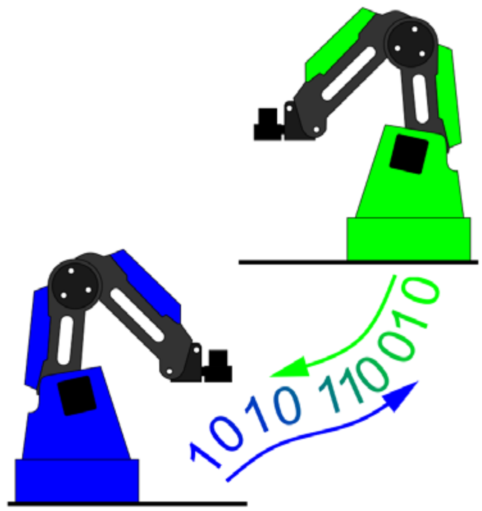
__________ 3. Start with the pick spot off to the side of the pallet and fill a pallet with one layer.

__________ 4. Complete a second layer after completing #3.

Activity 6: Handshaking – Dobot to Dobot

INTRODUCTION

Robotic arms need to communicate with other robots in a work cell, or factory. This is called **HANDSHAKING** and can be done between different machines, devices and robots. It is a very simple form of communication and is done with simple ones and zeros; or “ons” and “offs”.



In this activity you will learn how to make a robot handshake with another robot. Robot 1 will pass a part into another robot’s work envelope and then send a signal and go to a safe position. The other robot will then receive the signal, get the part, and place it somewhere else.

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

KEY VOCABULARY

- Handshake
- Signal
- Pull down resistor
- Optical Isolator
- Text
- Current limiting resistor

EQUIPMENT & SUPPLIES

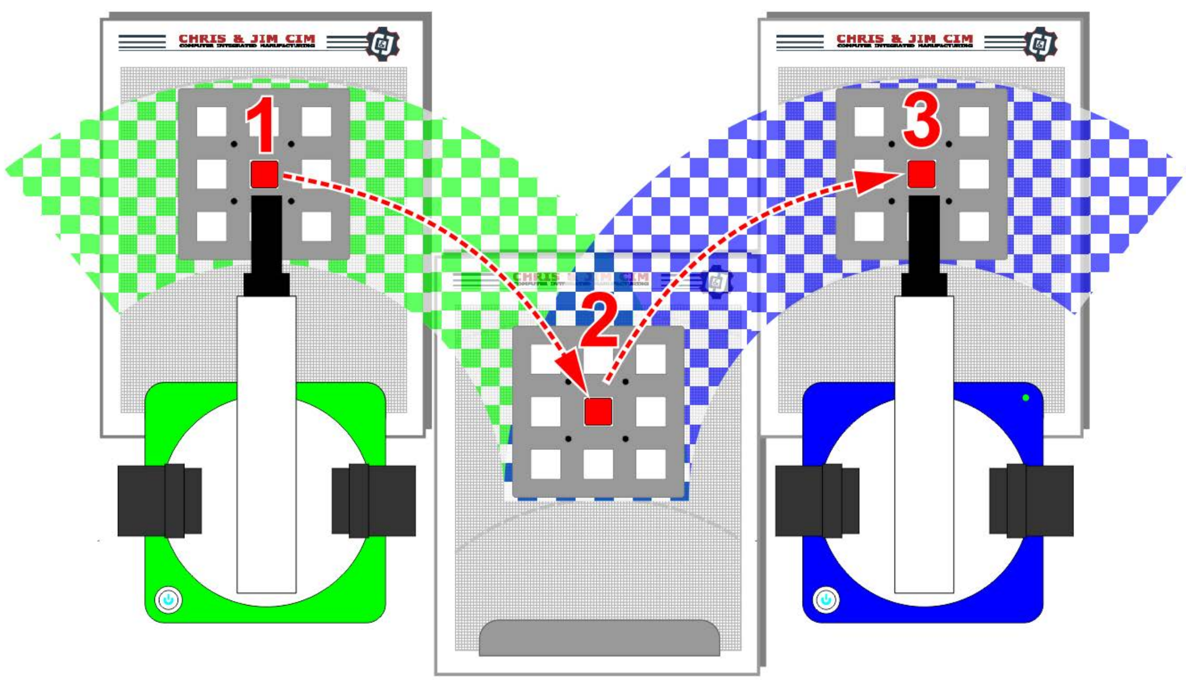
- Robot Magician
- Dobot Field Diagram
- 1” x ¾” cylinders or ¾” cubes
- Servo extension cables
- Dobot Input/Output Manual
- Breadboard/wire/4N25 Optical Isolator and 100 ohm & 4.7K ohm resistors
- DobotStudio software
- RobotC or other VEX control software
- Pneumatic Gripper or Suction Cup Gripper
- Handshake module
- VEX bump switch or limit switch
- VEX, PIC, Arduino may all be used in this activity, but wiring may vary.

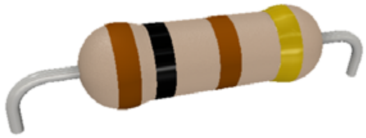
PROCEDURE

Open Loop System Block Diagram: Robot #1 acts as the input for robot #2. Robot #2 does not communicate back to robot #1 so there is no feedback. The Handshake Module acts as the device that helps make the handshake happen safely.

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. Be sure to ask your instructor if you have any questions.

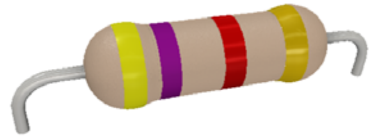
1. Set up both robots with suction cups and place a Dobot field diagram, taped to the work surface, between the two robots.
2. Wire the robot 1 to robot 2 through the handshake controller as shown below. Be sure that wires are not going to be pulled out by the motion of the robots.





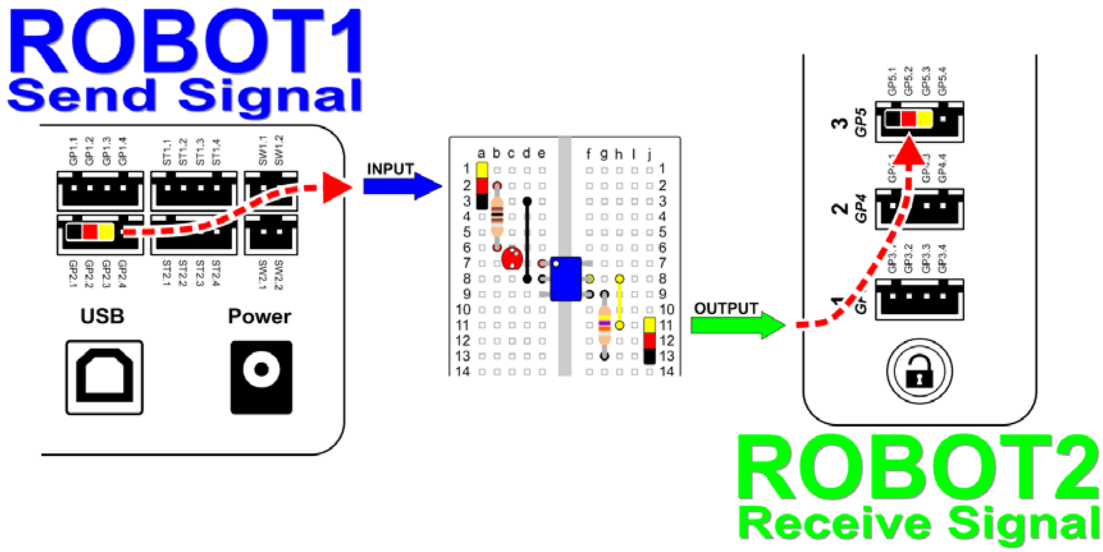
100 Ω - INPUT SIDE

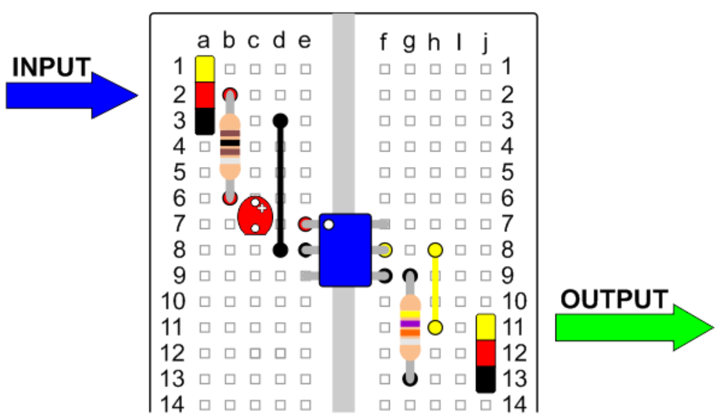
BROWN	BLACK	BROWN	GOLD
1	0	X10	5%



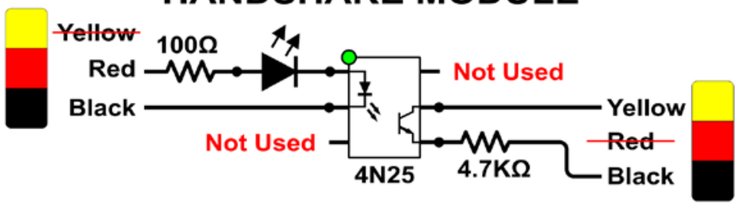
4.7k Ω - OUTPUT SIDE

YELLOW	VIOLET	RED	GOLD
4	7	X100	5%





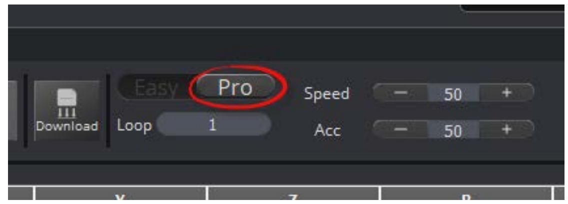
HANDSHAKE MODULE



Wire Robot #1 so that GP2 is wired to the input of the handshake module. Then wire the output of the handshake module to the Input of robot #2. This is labelled #3 on the arm. Please refer to the wiring diagram above. You can use servo extension cables to do the wiring.

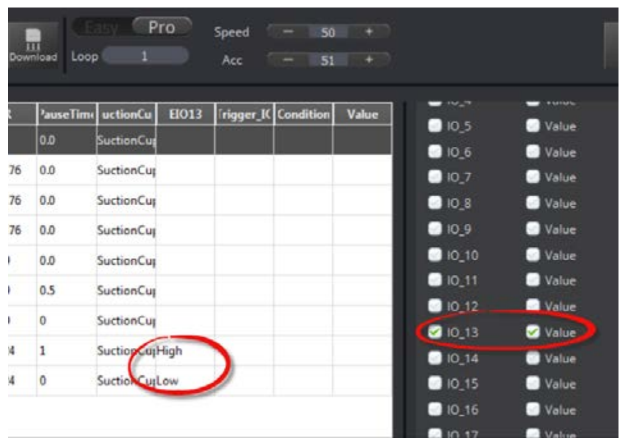
*Notice that on the **INPUT** to the handshake module you will use the RED and BLACK wires to trigger the Optical Isolator. On the **OUTPUT** side you will use the YELLOW and BLACK wires to trigger the input on the other robot.*

3. Be sure you are in Pro mode in the DobotStudio software.



When you re-open this program if you do not switch to Pro mode, it will not use the inputs and outputs and the program will ignore them!

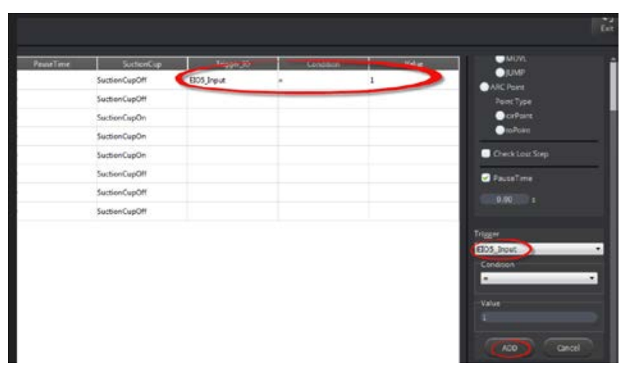
4. *Set up the Dobot Studio program for robot # 1 so that it moves the part from its position into the work envelope of the second robot. It needs to send a signal to EIO13 for 1 second (high), then turn the signal off (low)*



Be sure to use EIO13 as an output on the last two lines of code. Turn it on in the first one and pause for 1 second, then off on the second step. Use copy and paste to do this.

Also, add a check next to IO_13 as shown, then TEACH the position. This will add it to your program.

5. Set up the DobotStudio program for robot # 2 so that it waits until robot #1 sends a signal to pick it up, then place it somewhere else. Be sure to use EIO5 as the trigger input, and set it at High for 1 second, then turn it off in the next step.



WARNING

Be sure to consult the Dobot Input/Output manual if you want to use other inputs and outputs, as damage to your robot or your other equipment may result.

6. *Write down any notes that you think you may need to make this work:*

7. Once both programs are written, run the programs. If written correctly, robot #2 will wait for the signal from the first robot. If it does not work correctly, troubleshoot until it does.
8. *If your set up did not work correctly the first time, what did you have to do to make it work?*

CONCLUSION

1. *What would you have to do to make this program run five times without any human intervention? Explain fully below.*

2. *Copy and paste the psuedocode from your microcontroller program below.*

3. *What other inputs could you use on your robot to start this process? Use the Input/Output manual to answer this question, and do not attempt to try it without your instructor's permission.*

4. *What other outputs could you use on your robot to start this process? Use the Input/Output manual to answer this question, and do not attempt to try it without your instructor's permission.*

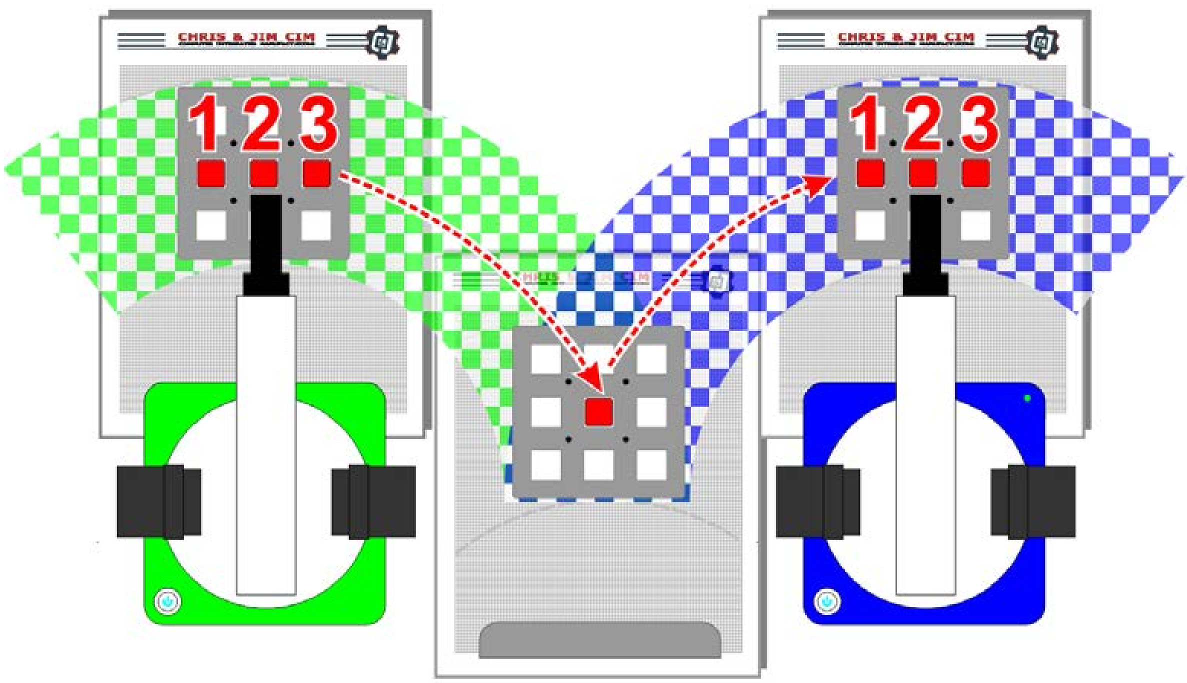
GOING BEYOND

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

_________ 1. Add an input switch to the first robot to start the whole process.

_________ 2. Make the robots **palletize** three **cubes** as the diagram below shows.

Start with three cubes on the first pallet, use the second pallet as a buffer to do the hand off, and then have the second robot place them on pallet 3. Be sure to adjust the **roll angle** accordingly.

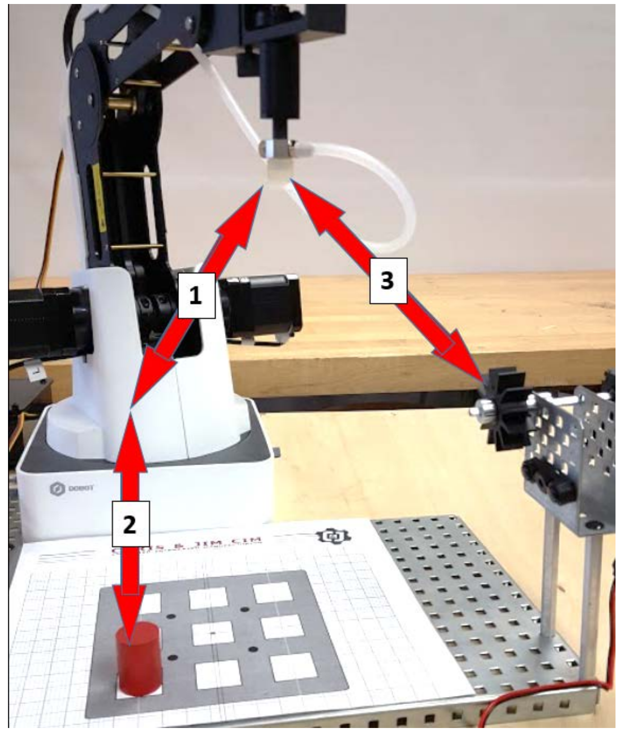


Activity 7: Handshaking: Dobot to Microcontroller

INTRODUCTION

Robotic arms sometimes need to communicate with other machines in a work cell, or factory. This is called “Handshaking” and can be done between different machines, devices and robots. It is a very simple form of communication and is done with simple ones and zeros; or “ons” and “offs”.

In this activity you will learn how to make a robot handshake with a simulated machine; a grinder. You will make the robot talk to the grinder to turn it on during an automated grinding operation. Remember, this is CIM, we do not want to keep the grinder running all the time; we need to conserve energy, time, and resources, so the grinder needs to stop, and the robot will then replace the part.



power on. ALWAYS turn it off before making connections or damage to the robot could occur.

KEY VOCABULARY

- Handshake
- Optical Isolator

EQUIPMENT & SUPPLIES

- Robot Magician
- Dobot Field Diagram
- 1” x ¾” cylinders or ¾” cubes
- Servo extension cables
- Dobot Input/Output Manual
- Breadboard/wire/4N25 Optical Isolator and 100 ohm & 4.7K ohm resistors
- VEX, PIC, Arduino may all be used in this activity, but wiring may vary.
- DobotStudio software
- RobotC or other VEX control software
- Pneumatic Gripper or Suction Cup Gripper
- Handshake module
- Normally open digital switch
- VEX parts: various for building the grinder including a baseplate, motor & controller.

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. Be sure to ask your instructor if you have any questions.

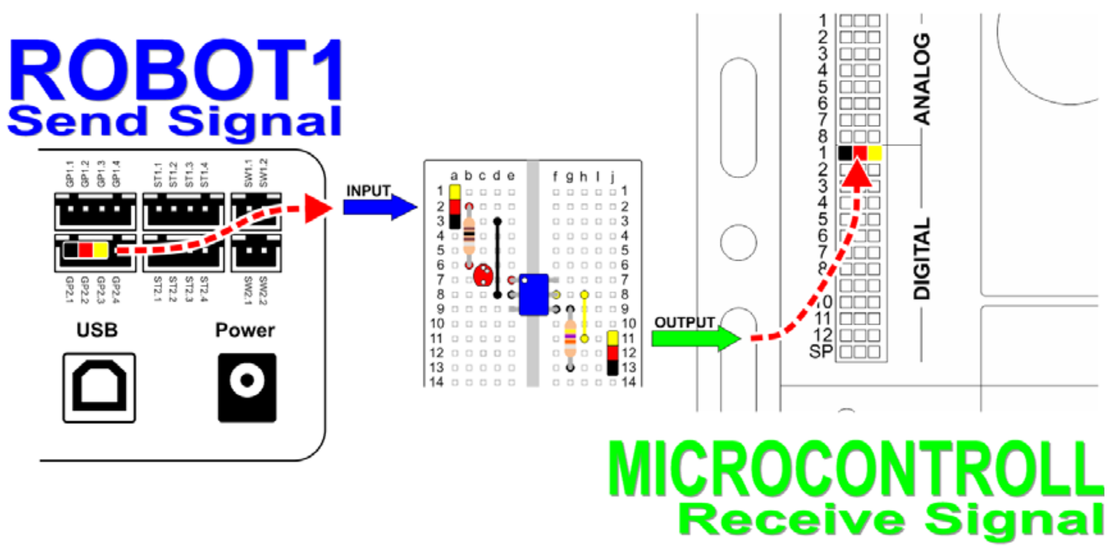
1. Wire the robot to the VEX Cortex through the handshake controller as shown below. Any other microcontroller, such as an arduino a PIC or a Raspberry Pi may be used as well.

100 Ω - INPUT SIDE

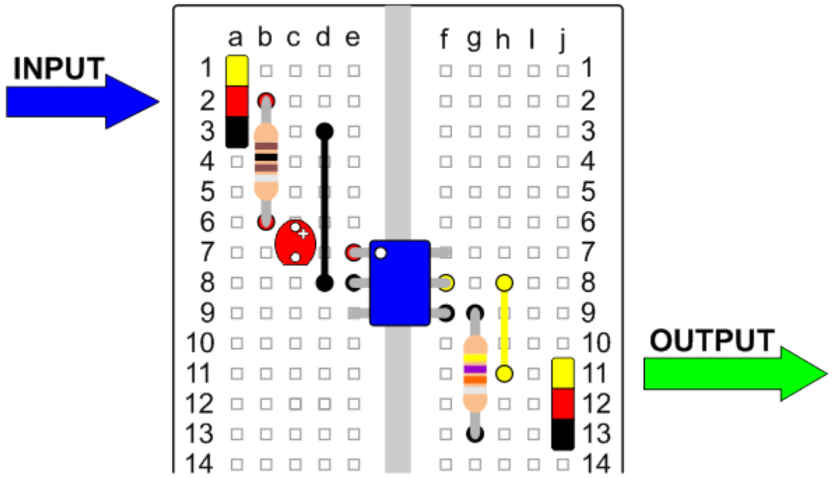
BROWN	BLACK	BROWN	GOLD
1	0	X10	5%

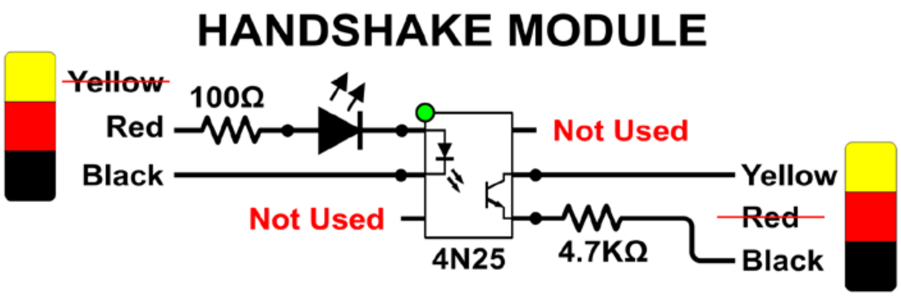
4.7k Ω - OUTPUT SIDE

YELLOW	VIOLET	RED	GOLD
4	7	X100	5%



Back of the robot: GP2.1 & GP2 2.3 *Optical Isolator* *Cortex: Digital Input*





Connect EIO13 on the back of the robot to the input of the handshake controller, and then wire the output of the handshake controller to digital input #1 on the VEX Cortex. Use servo extensions to do this.

NOTES:

*Notice that on the **INPUT** to the handshake module you will use the RED and BLACK wires to trigger the Optical Isolator. On the **OUTPUT** side you will use the WHITE and BLACK wires to trigger the input on the VEX Cortex.*

If you are not using the handshake module, but some other form of optical isolator,just understand that the signal from the back of the robot is coming from the Black and Red wires from the extension cable.

These correspond to the signal being sent from pins GP2.1 and GP2.2 on the back of the robot.

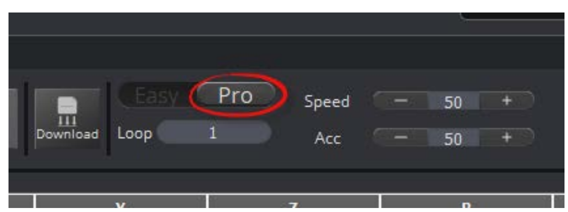
Be sure to consult the Dobot Input/Output manual if you want to use other inputs and outputs, as damage to your robot or your other equipment may result.

2. Wire the *normally open digital switch* as an input as done in previous activities.

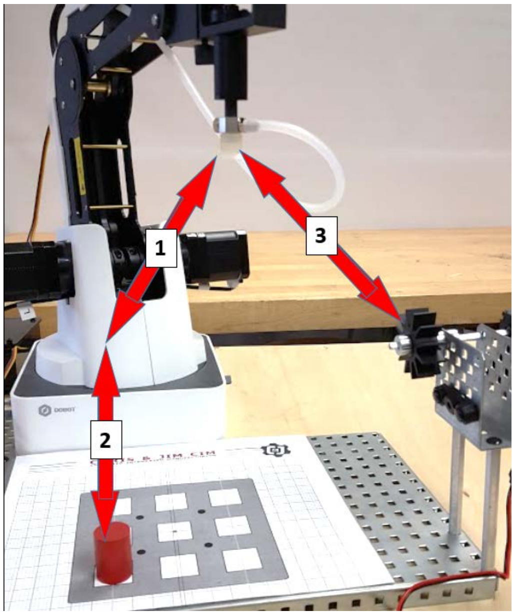
Use a servo extension cable to attach the VEX limit switch to GP5 as shown in the diagram above. Always be sure the black wire on the extension cable matches the black wire on the switch. For more info on how to construct this please refer to the previous activity.

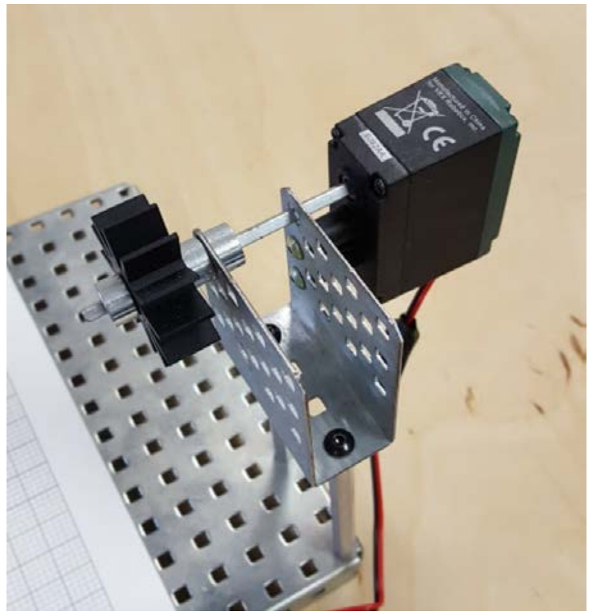
3. Attach the *Air Pump/Vacuum Gripper* kit or the *Pneumatic Gripper* to the robot as done in previous activities.

4. Be sure you are in Pro mode in the DobotStudio software.



When you re-open this program if you do not switch to Pro mode, it will not use the inputs and outputs!





5. *Set up the Dobot Studio program so that it moves the part through the motions described above.*

6. *Build a simple grinder to simulate a manufacturing process. In this case VEX parts are used to simulate a simple grinder.*

7. Write the RobotC or microcontroller code that will make the robot complete the following tasks:
    a. Send the robot home.
    b. Wait for the limit switch to be hit to start the program.
    c. Continuously do the following, every time the limit switch is hit.
        i. Go get the part from the pallet.
        ii. Bring the part to the grinder.
        iii. Turn on the grinder.
        iv. Complete the grinding operation.
        v. Return the part to the pallet.

HELPFUL TIPS

VEX Users: *Be sure to set up the input to the VEX Cortex as a* ***Touch Sensor****, not a* ***Digital IN****! If you use a* ***Digital In****, "off" will be "on", and "on" will be "off".*

8. *Write down any notes that you think you may need to make this work:*

9. Once both programs are written, Run the DobotStudio program , and the RobotC or microcontroller program. If written correctly, the robot will wait for the press of the switch, and the RobotC program will wait for an input from the grinder.
   If it does not work correctly, troubleshoot until it does.
10. *If your setup did not work correctly the first time, what did you have to do to make it work?*

CONCLUSION

1. *What would you have to do to make this program run five times without any human intervention? Explain fully.*

2. *What is the order of operations for successfully starting this setup? Which program has to start first? Explain why.*

3. *Which gripper did you choose to complete this activity? Justify your choice*

4. *What's the pseudocode that you used for your microcontroller program? Copy and paste it here.*

5. *In RobotC, If you use a Digital IN, Off will be On, and On will be Off. Explain why this is.*

GOING BEYOND

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

__________ 1. Use a sensor to make this loop multiple times. Make it so the robot goes home after the first cycle and waits for a part to be placed before starting again.

__________ 2. Complete Going Beyond #1 above and make it palletize the product when finished.

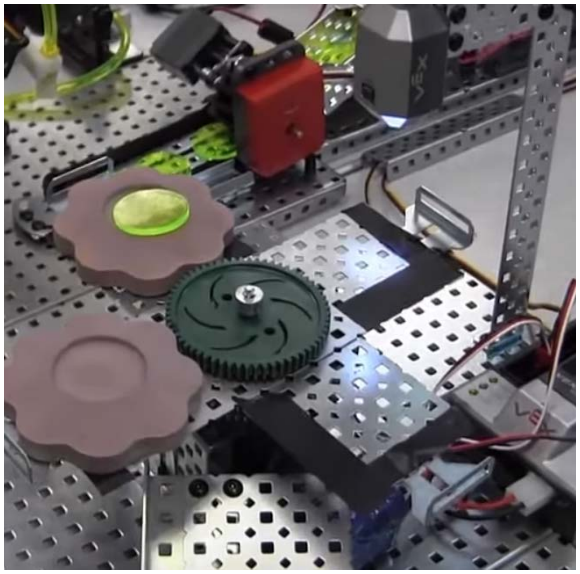
Activity 8: Workcell Design

INTRODUCTION

A robotic workcell is defined as the complete environment around a robot. This environment may include tools, machines and/or other robots.

In this activity you will use a robot and a microcontroller system to recreate a workcell. Your workcell will incorporate all of the devices that you have learned about in previous activities including:

- Inputs & outputs
- Sensors
- Machines
- Robots



An example of an assembly operation using robots and VEX components

Due Date: ________________

KEY VOCABULARY

- Handshaking
- Workcell
- Output
- Nesting
- Optical Isolator
- Sensor
- Input
- Palletize

EQUIPMENT & SUPPLIES

- Robot Magician
- Microcontroller System & Components
- 1" x ¾" cylinders or ¾" cubes
- Servo extension cables
- Dobot Input/Output Manual
- Breadboard/wire/4N25 Optical Isolator and 100 ohm & 4.7K ohm resistors
- DobotStudio software
- RobotC or other VEX control software
- Pneumatic Gripper or Suction Cup Gripper
- Handshake device
- Input & Output devices
- VEX, PIC, Arduino may all be used in this activity, but wiring may vary.

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. Be sure to ask your instructor if you have any questions.

1. Using the list of manufacturing process below, find an example in a video on the internet that you can recreate a simulation of. Fill in the blanks below after you have your instructor's approval.

• Assembly (Ex. Spraying)	• Joining (Ex. Welding)
• Forming (Ex. Extrusion)	• Finishing (Ex. Spraying)
• Separating (Ex. Grinding or cutting)	• Conditioning (Ex. Dipping)
• Casting or molding (Ex. Injection Molding)	

2. Be sure to note any parameters that are given to you by your instructor. Take notes in the space below.

3. Be sure to a pick a process that can be easily simulated with the materials given to you by your instructor.
   My topic: ________________________________

4. In the time allotted for this project design a workcell that includes the following:
   a. An accurate pick and place routine that uses a robot.
   b. At least one input that controls a process.
   c. At least one output that controls a process.
   d. A simulation of a manufacturing process.
   e. A palletize or nesting routine.
5. Be sure to have it graded by your instructor when complete and be sure to do a demonstration to your classmates!

Be sure to consult the Dobot Input/Output manual if you want to use other inputs and outputs, as damage to your robot or your other equipment may result.

CONCLUSION

1. *Describe the manufacturing process you chose and explain how it works. (At least 4 to 5 sentences.)*

2. *Make a flowchart/Process flowchart. of your workcell as indicated by your instructor in the space below.*

3. *What's the pseudocode that you used for your microcontroller program? Copy and paste it here.*

4. *What are the inputs you used in your workcell?*

5. *What are the outputs you used in your workcell?*

6. *Explain how nesting parts is important in any manufacturing process.*

GOING BEYOND

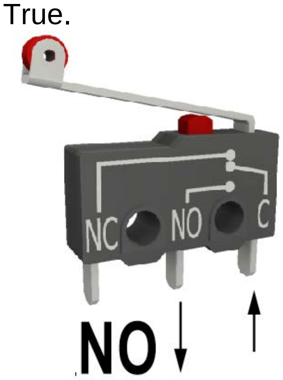
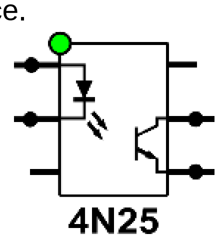
Finished early? Try some of the actions below. When finished, show your instructor and have them initial on the line.

__________ 1. Make your workcell communicate with someone else in your class. When your process ends, theirs begins.

__________ 2. Put your workcell together with someone else in class and make it do BOTH processes, then palletize the finished product.

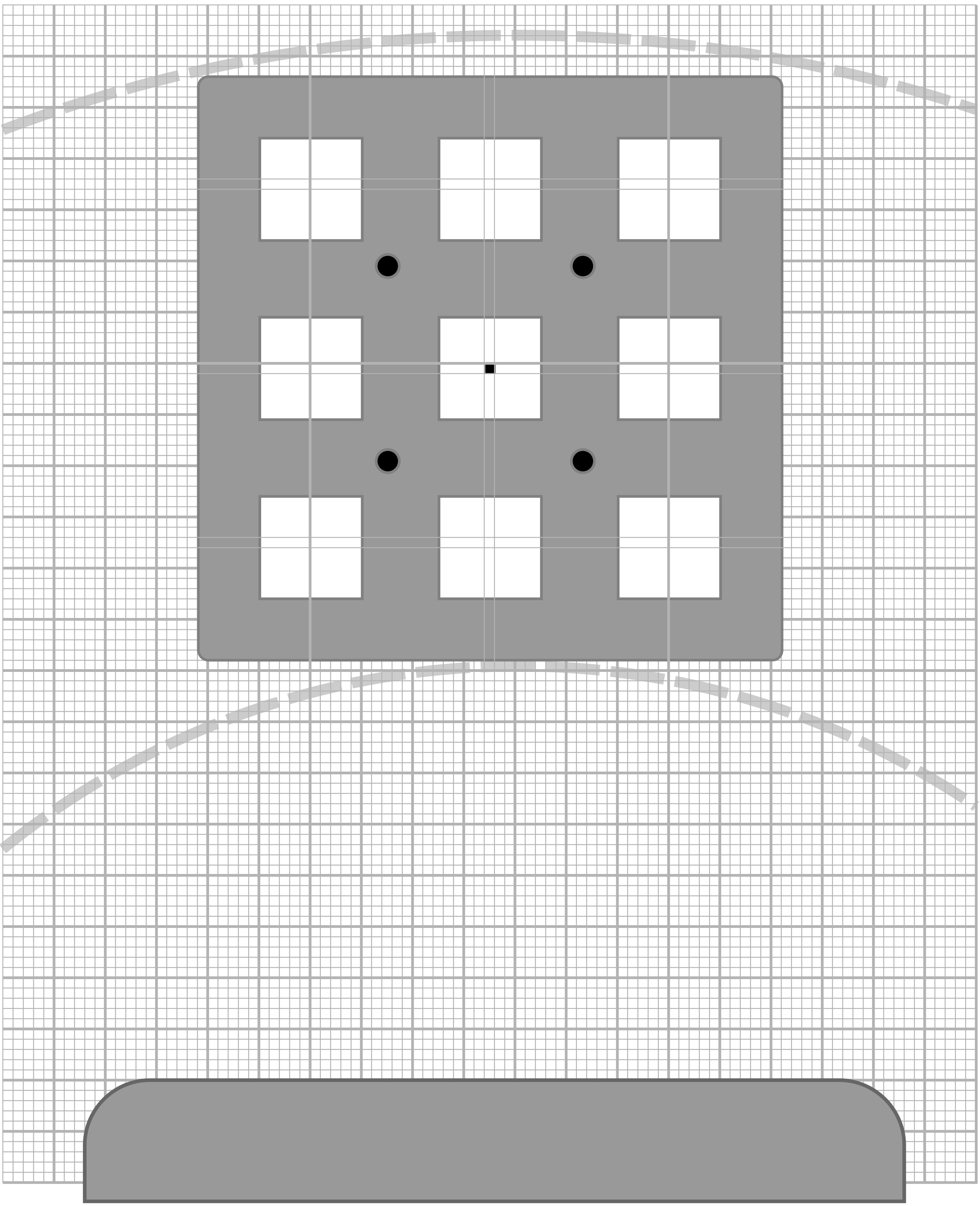
Robotics Glossary

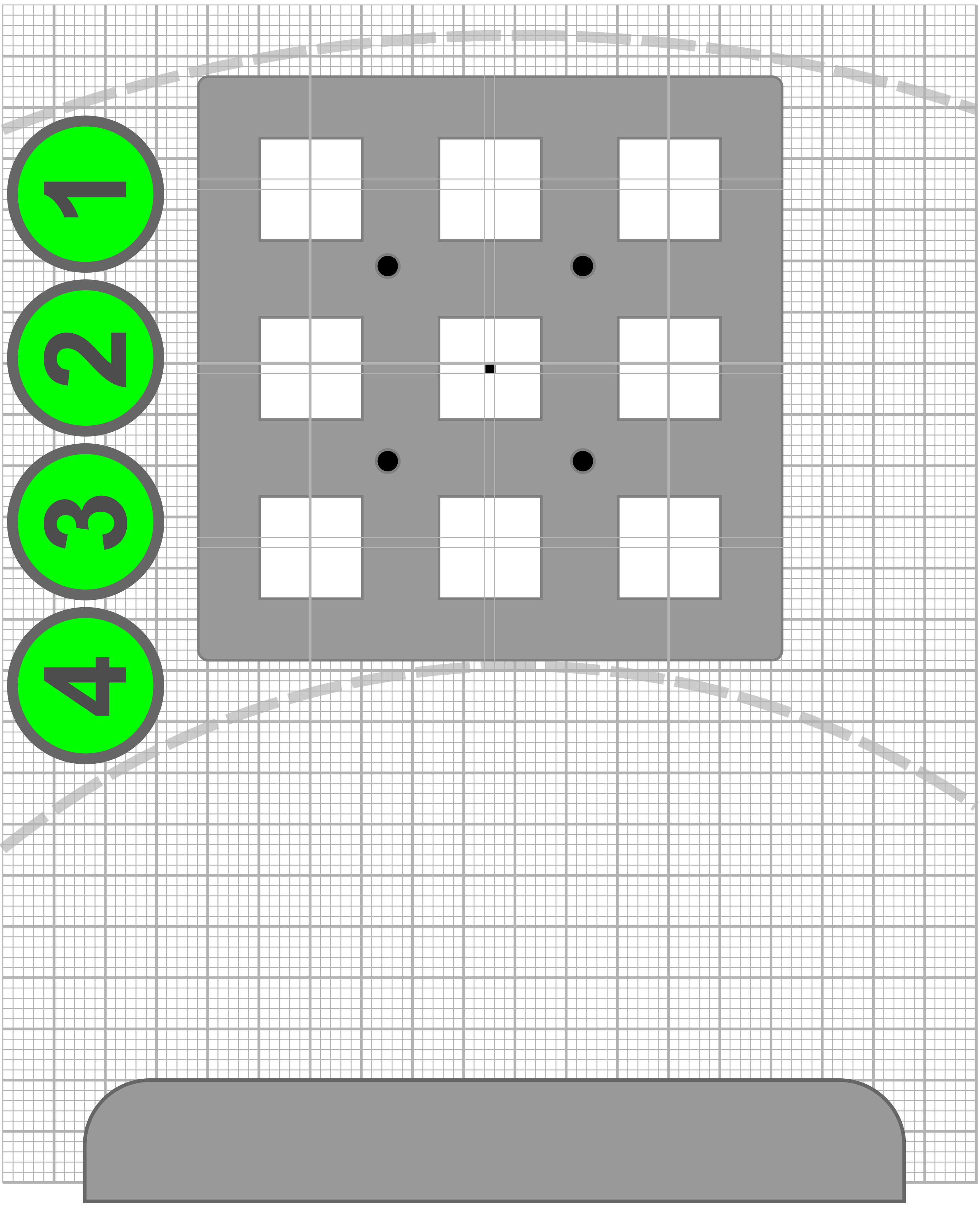
Vocabulary	Lesson/ Presentation	Definition
Active sensors	Communication	Sensors that require an external power supply to operate.
Analog	Communication	A type of signal that has a range of values. A good example is an 8-bit light sensor with at least 256 different values.
Axis Movement	1	Movement of a robot's wrist in a straight line on the X, Y or Z axis.
Current limiting resistor	6	A resistor used in a circuit to limit the current going to a component such as a light emitting diode (LED)
Degrees of Freedom	Robots in Industry	The range and flexibility of motion. Each added degree of freedom adds greater range of motion to the robot's tooling within its work area. Also see Roll, Pitch and Yaw.
Digital	5	Either on or off, no in between. Generally represented by a 1 or 0, or in electronics terms; 5 volts or 0 volts.
Drive system	Robots in Industry	The power or motors that are used to control the positioning of the robotic arm. Usually electric but may be hydraulic or pneumatic as well.
Electric drive system	Robots in Industry	A drive system used for high accuracy, repeatability and speed. Used to control motors, servos, or stepper motors.
End of arm tooling (EoAT)	1	The tooling added to the end of a robot's arm that allows it to perform specific operations. Also known as an end effector.
Handshaking	6,7 Communication	Handshaking is defined as safe communication between two or more, like or unlike, pieces of technology.
Home	1	A position within the robot's work envelope designated as a starting point for the operation.
Hydraulic drive systems	Robots in Industry	A drive system used for larger robots that require large amount of power. Linear movements are produced by hydraulic pistons while rotary is produced by rotary vanes.
Input	Robots in Industry	A signal or value that is received by the robot. These values can be received from sources such as sensors, other devices, or other robots.
Joint movement	1, 2	The movement of a robotic arms end effector defined by the movement of its individual joints.
Linear movement	1, 2	The same as an axis movement; Movement of a robot's end effector in a straight line on the X, Y or Z axis.
Loop	1,3,5	The ability to repeat a given set of instructions or code a specific number of times

Main controller	Introduction	The brain of the robotic system. Used to control the motion of and programming of the robot as well as control various inputs and outputs and communicate with other elements in a work cell.
Nesting	Applications	Making parts fit most efficiently on a pallet or in a given space.
Normally closed	5	A digital switch, that when activated, turns OFF. Useful in handshaking when you want something to happen when an input signal turns off. The switch in the current state below will read as On or True. If the switch is pressed, it will read as Off or False. 
Normally open	5	A digital switch, that when activated, turns ON. Useful in handshaking when you want something to happen when an input signal turns on. The switch in the current state below will read as Off or False. If the switch is pressed, it will read as On or True. 
Optical isolator	6,7	An electronic device that separates two unlike voltages or currents in a robotic communication system. It accomplishes this using an infrared LED and a light sensor embedded in a device. 

Output	Communication	An output produces an action. Some examples are motors, lights, and displays. An output can be a simple signal sent from a robot to another device such as a tool, machine or other robot.
Palletizing	2,4	An automated process that uses a robot to load and unload parts, containers, or boxes onto pallets for storage and shipping.
Passive sensor	Communication	Sensors that detect inputs from the physical environment without external power.
Payload	Introduction	The size and weight of the material that a robotic arm can safely lift.
Pick and place	Applications	When a robot retrieves parts from one location and consistently places them in a new location.
Pitch	4	The degree of freedom of a robotic arms end effector around its Y axis.
Pneumatic drive system	Introduction	A drive system used in smaller robots. Used to control rotary actuators or sliding joints. Typically used for high speed operations and limited movements.
Pull-down resistor	5,6	A resistor used in an electrical circuit to force a signal to be low when not activated (0v). This prevents a signal from floating in between a 1(5v) and 0(0v) in a digital circuit.
Pull-up resistor	5,6	A resistor used in an electrical circuit to force a signal to be High (5v) when not activated. This prevents a signal from floating in between a 1(5v) and 0(0v) in a digital circuit.
Ramping	1	To accelerate or decelerate the speed with which a robot moves.
Record	1-7	To save a position with a robot arm by actually moving the robot to that position and then storing the values of all the robot's joints.
Relative coordinates	1	A cartesian coordinate system where each successive point is relative to the point before it. Also known as incremental.
Relative positions	2	A system of recording positions where each point is relative in X, Y, and Z coordinates to all the other points in a program.
Robot accuracy	1	How close a robot's actual movement is to a given position.
Robot repeatability	1	A robot's ability to return to a given position multiple times.
Robotic arm	Introduction	The positionable part of the the robot that is used to locate and position the end of arm tooling.
Roll	4	The degree of freedom of a robotic arms end effector around its Z axis

Roll angle	4	Adjusting this angle allows a robot’s end of arm tooling to line up and nest parts on a pallet.
Sensor	Introduction	Inputs that provide feedback and bring in a variety of data into the robot.
Suction	3,5	The gripper or end of arm tooling that uses vacuum and a flexible suction cup to pick up parts easily.
Teach	1-7	To save a position with a robot arm by typing in an X, Y and Z value and storing the position.
Teach pendant	Introduction	A handheld device used to manually control, program, and troubleshoot a robotic arm without the need for a full control terminal.
Tool center point	3,5	The X, Y and Z value recorded or taught in robotics that represents where the work is actually being done in space by the robot's end of arm tooling. (TCP)
Touch up	3	To easily correct or round saved points in a robotics program by manually adjusting X, Y, and Z values in the control software.
Vacuum	3,5	The creation of negative pressure that allows a robot to pick up an object easily.
Work cell	Introduction	The complete environment around a robot. May include tools, machines and/or other robots.
Work envelope	Introduction	Defined as the range and area each robot may work within.
Yaw	4	The degree of freedom of a robotic arms end effector around its Y axis

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