Tormach ZA6
Industrial Robotic Arm Training

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Technology & Engineering Education

Tormach ZA6 Movement and Waypoints

Instructor Resources Page

Example Python Code for introduction:
Note you must add in a folder titled sounds within the robot programs folder

Download Code Here

STL file for 3D printed EoAT

Download Model Here

Tormach ZA6 Movement and Waypoints

SCAN ME

Video Clip
Click on Picture

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 Jogging. We will have the robot move joint positions as well as cartesian coordinates. We will also use a method of saving waypoints called TEACHING. This is where we can record positions of the robot for repeat playback

Tormach ZA6
Movement and Waypoints

As a rule, the operator of the robotic arm is responsible for making sure the work envelope is clear before running a robot program as well as always within reach of an emergency stop for the machine.

KEY CONCEPTS

- Different ways that robot arms can move: Move Linear and Move Joint
- Starting up the ZA6 Robotic Arm
- Different ways to Jog and adjust the ZA6 Robotic Arm
- How to record a waypoint
- How to organize and write a code with conversational programming
- How to utilize a robot arm to move through a group of points by using 3D printed end of arm tooling and writing the word CIM.
- How to use PathPilot user interface with the ZA6 Robotic Arm

KEY VOCABULARY

- Relative Coordinates
- Joint movement
- Axis movement
- Work envelope
- Accuracy
- Waypoint
- Linear move
- Home
- Loop
- End Effector
- End of Arm Tooling (EoAT)

EQUIPMENT & SUPPLIES

ZA6 Robotic Arm
White Board
3D Printed EoAT (files provided below)
Expo Marker
Path Pilot software
Dial Indicator

Tormach ZA6
Movement and Waypoints

PROCEDURE

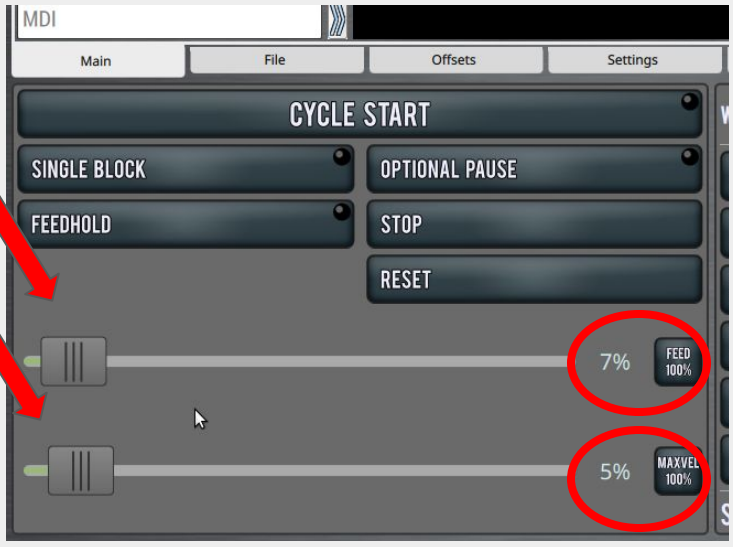
Caution: NEVER wire anything to the ZA6 while it has power on. ALWAYS turn it off before making connections or damage to the robot could occur.

Air lines tucked away

1. Prep the Robot- End of Arm Tooling is not needed for step 1. If there are air lines run on the machine, tuck them up so they are out of the way for the robot to move. Locate both the Emergency stop button and the secondary Emergency stop switch. When the machine is turned on, immediately turn down both the Feed and Max. Velocity to 10% or less.

Locate both Emergency Stop Devices

Adjust Speeds when Robot is on



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Movement and Waypoints

2. Watch the below QUICK TIP video for a reference, then answer the below questions. Do not take the robot out of reset before instructor approval.

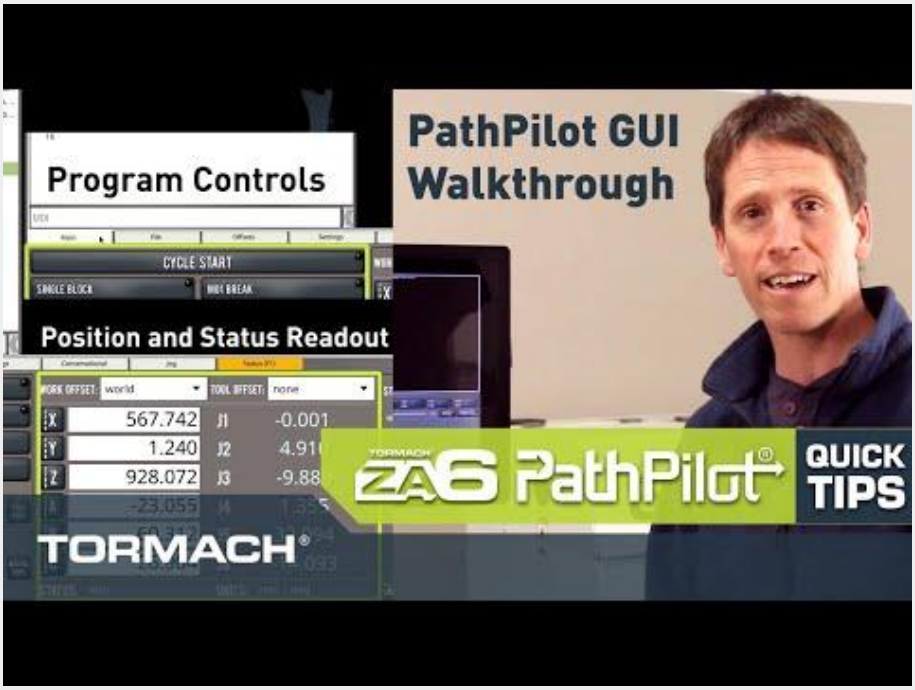
The Persistent controls (controls on the bottom) are unique. As you navigate through different control options above them they do what?

Name 3 features that you can control with the Program controls

What can you expect to see on the Main tab of the Notebook section in the controls?

What can you expect to control in the CONVERSATIONAL tab of the Notebook section in the ZA6 controls?

What can you expect to control in the JOG tab of the Notebook section in the ZA6 controls?



Video Clip
Click on Picture

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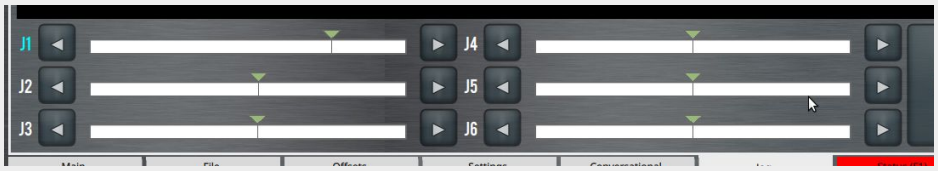
Movement and Waypoints

3. Jogging the Machine! Watch the below Quick Tips video clip.

Set the jog speed of the robot to no more than 25% speed. Use the Jog controls to move the robot. Fill in the below chart to record what happens.



	Did you Hold the Arrow Left or Right?	Description In/ Out/ Up/ Down/ Left/ Right/ Clockwise/ Counterclockwise
J1		
J1		
J2		
J2		
J3		
J3		
J4		
J4		
J5		
J5		
J6		
J6		

Video Clip
Click on Picture

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4. Testing Accuracy & Repeatability.

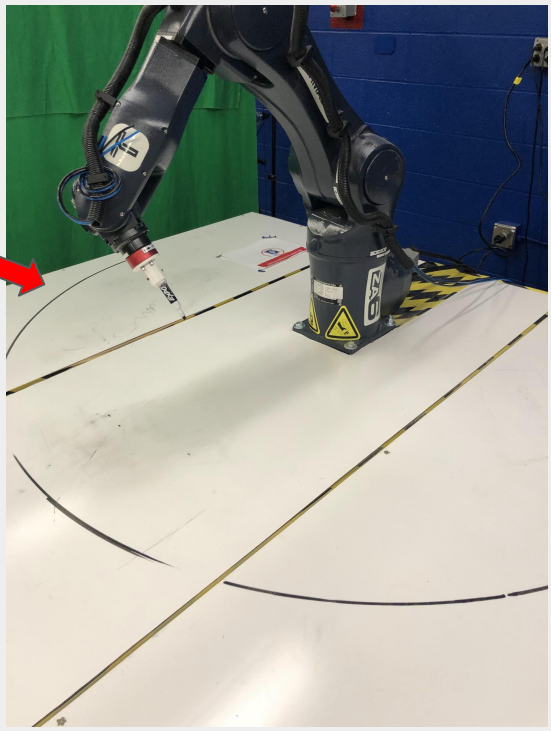
Set up a Dial Indicator within the work envelope to test your machines accuracy and repeatability.

Terms to know:

Work Envelope- the range of motion over which a robot arm can move.In practice, it is the set of points in space that the end effector can reach.

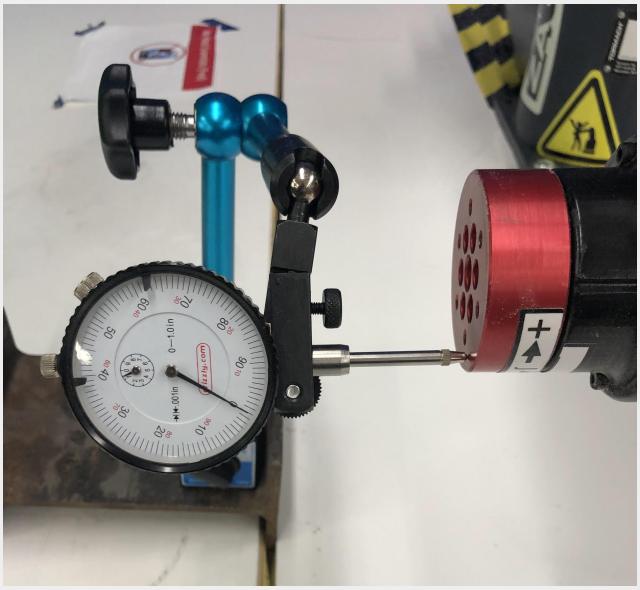
Accuracy- the degree to which the result of a measurement to the correct value.

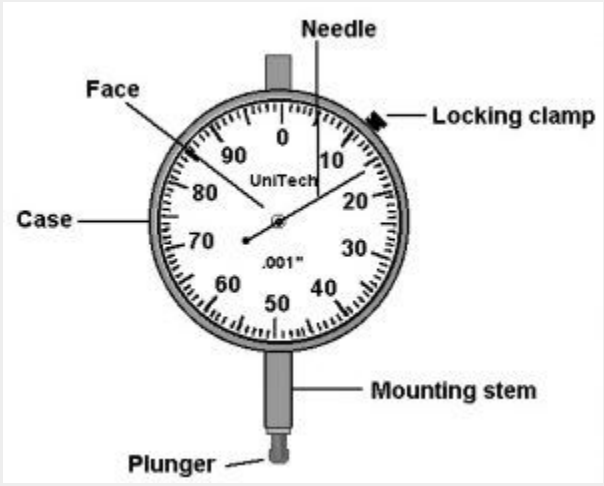
Repeatability- allows you to measure how close a particular result or set of data is compared to the same measurement



What Joint number will you be testing for accuracy?
How are you setting up the dial indicator to test the movement?

5. Jog the robot until compresses the dial indicator plunger. Then zero your indicator at that point.





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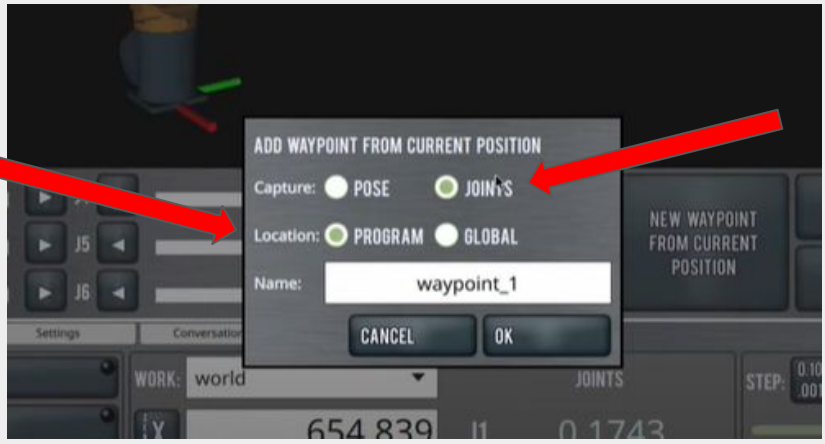
Movement and Waypoints

6. Record a waypoint of the robot while it is in contact with the indicator, capture the joints and store it locally. It is good practice to name your waypoints

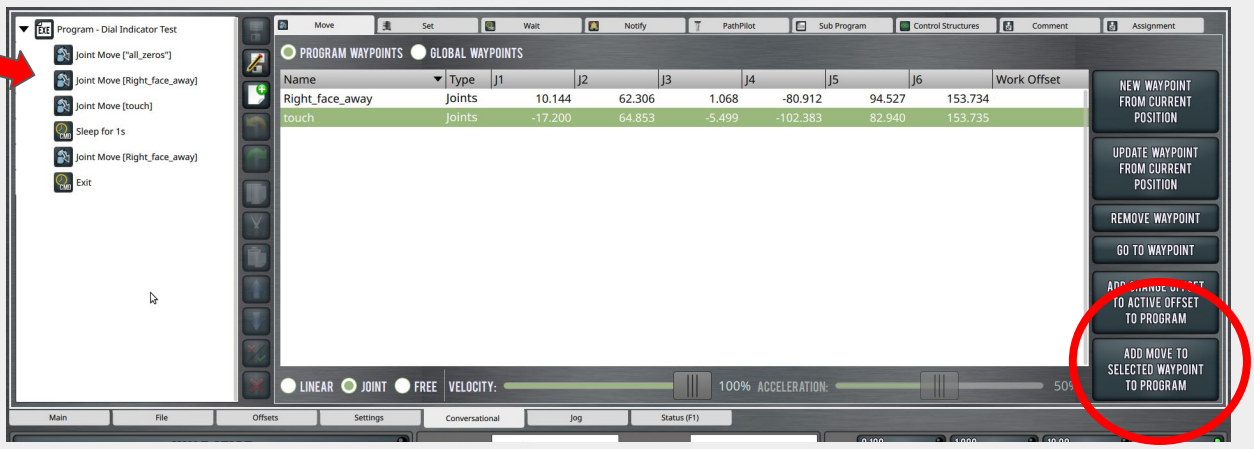


7. Jog the robot away from the indicator using the joint that you are testing and record another waypoint, repeating the process from the previous step.

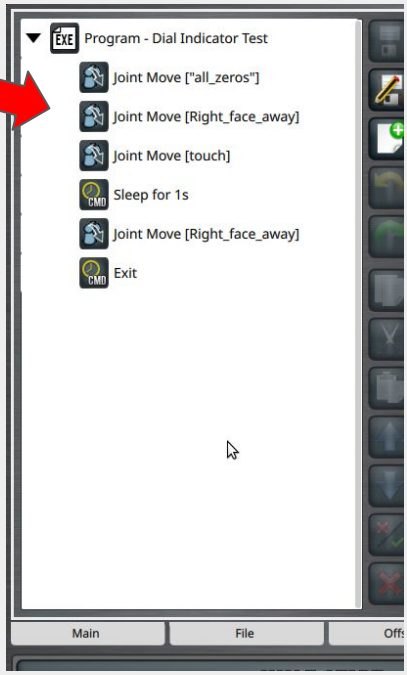
8. Using the **Conversational Tab** create a robot program. Click on your desired waypoint, then click Add Move To Selected Waypoint to Program. See example process on the following page:

Quick Tip:
There are pre-programmed waypoints available in the GLOBAL WAYPOINTS area.

This program starts with “joints all zeros” then goes to the local waypoints



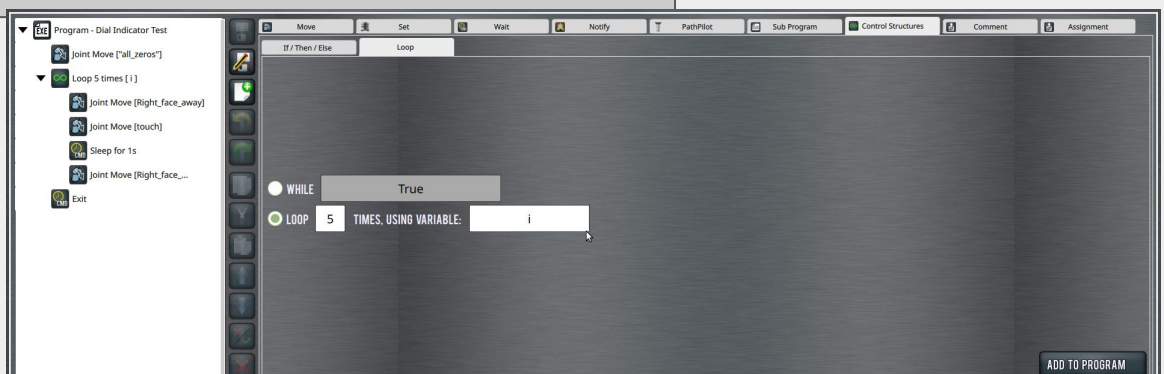
Tormach ZA6
Movement and Waypoints



9. After you have your program set, have your instructor check your work! Double check your speeds and run your program.

Did your program run as expected? Why or why not? What did you have to do to adjust your program (if anything)?

10. Add a delay between contacts to allow yourself to read the dial indicator, then add a loop (x5) to your program to test repeatability.



Tormach ZA6
Movement and Waypoints

Fill in the attached chart to record accuracy and repeatability of a joint on the robotic arm. Record how far away from 0 each trial is.

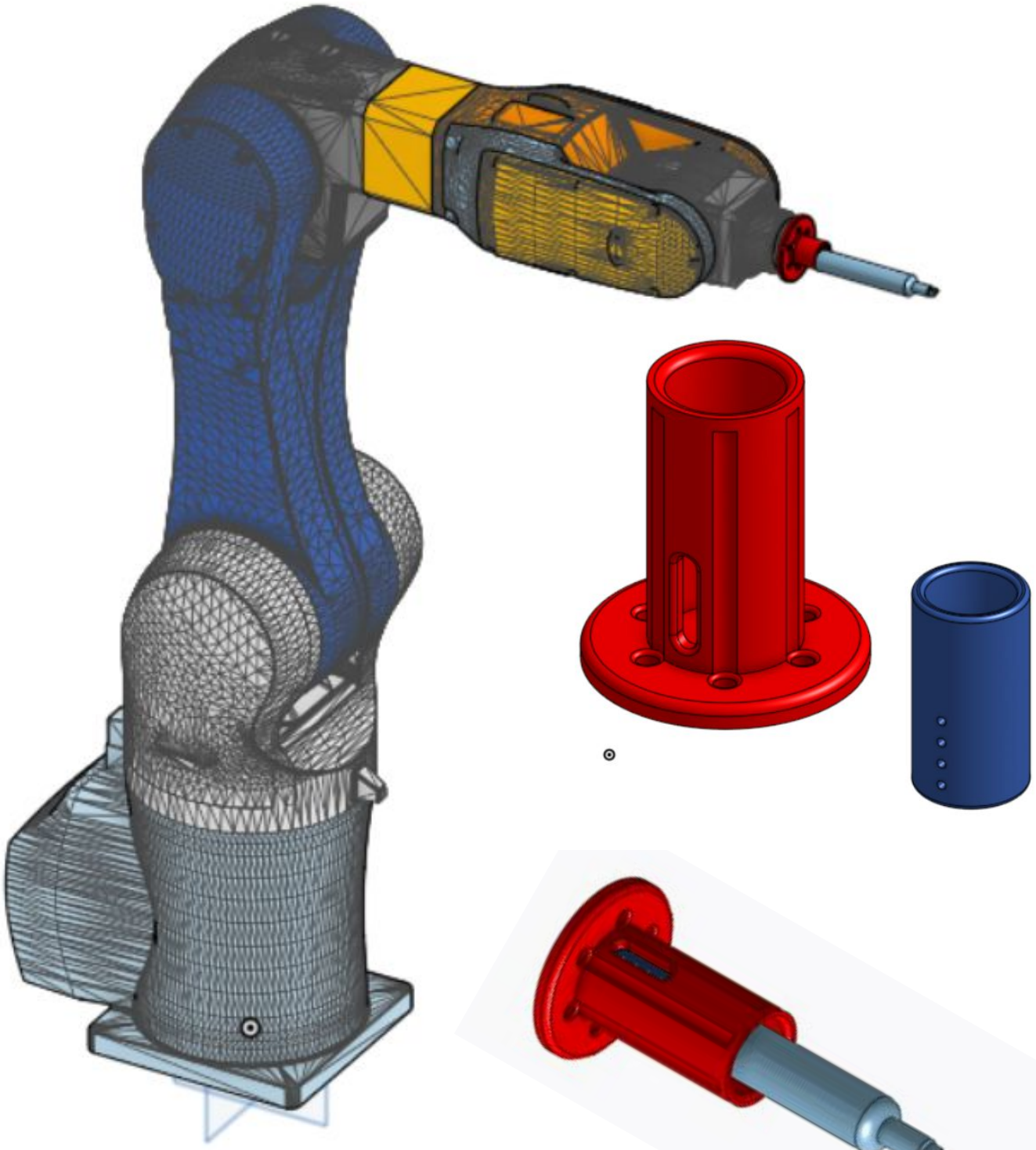
	10% Feed/ Acceleration	20% Feed/ Acceleration	30% Feed/ Acceleration
1			
2			
3			
4			
5			

Did your program run as expected? Why or why not? What did you have to do to adjust your program (if anything)?

Tormach ZA6
Movement and Waypoints
Part 2- creating a program with End of Arm Tooling

SCAN ME

Download the End of Arm Tooling for 3D Printing:
https://www.thingiverse.com/thing:5355976



Tormach ZA6
Movement and Waypoints Pt 2

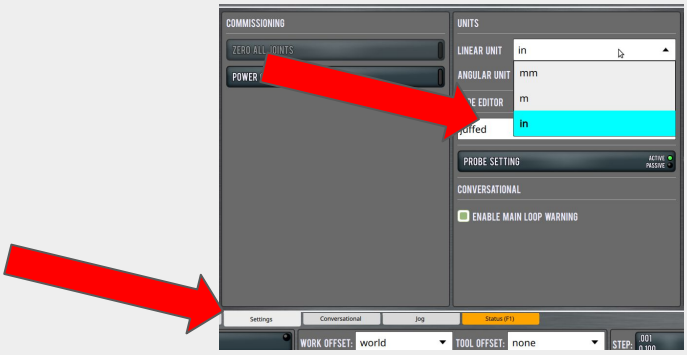
11. 3D print and assemble the Expo Marker holder onto the robot. This is an example of End of Arm Tooling for a robotic arm.

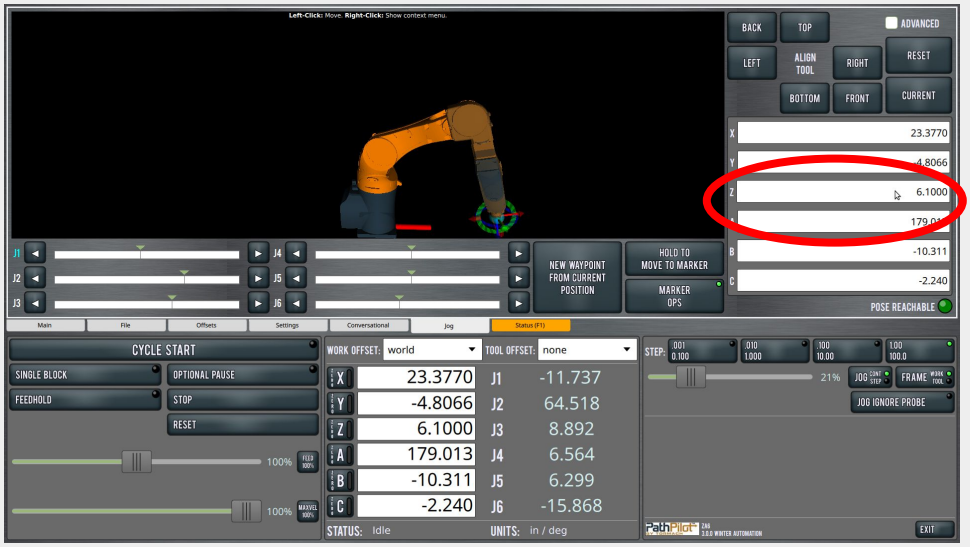
End of arm tooling (EoAT) can be attached directly to the red “puck” at the end of the ZA6 robot

The Expo marker holder has a spring in between 2 sleeves. What purpose do you think the spring serves in this tool?

12. In the settings tab change the units to inches. Jog the robot down slowly until the tip of the marker barely touches the white board surface. Record the value of the Z coordinate below (The robot should never go below this point or the EoAT will crash into the table).

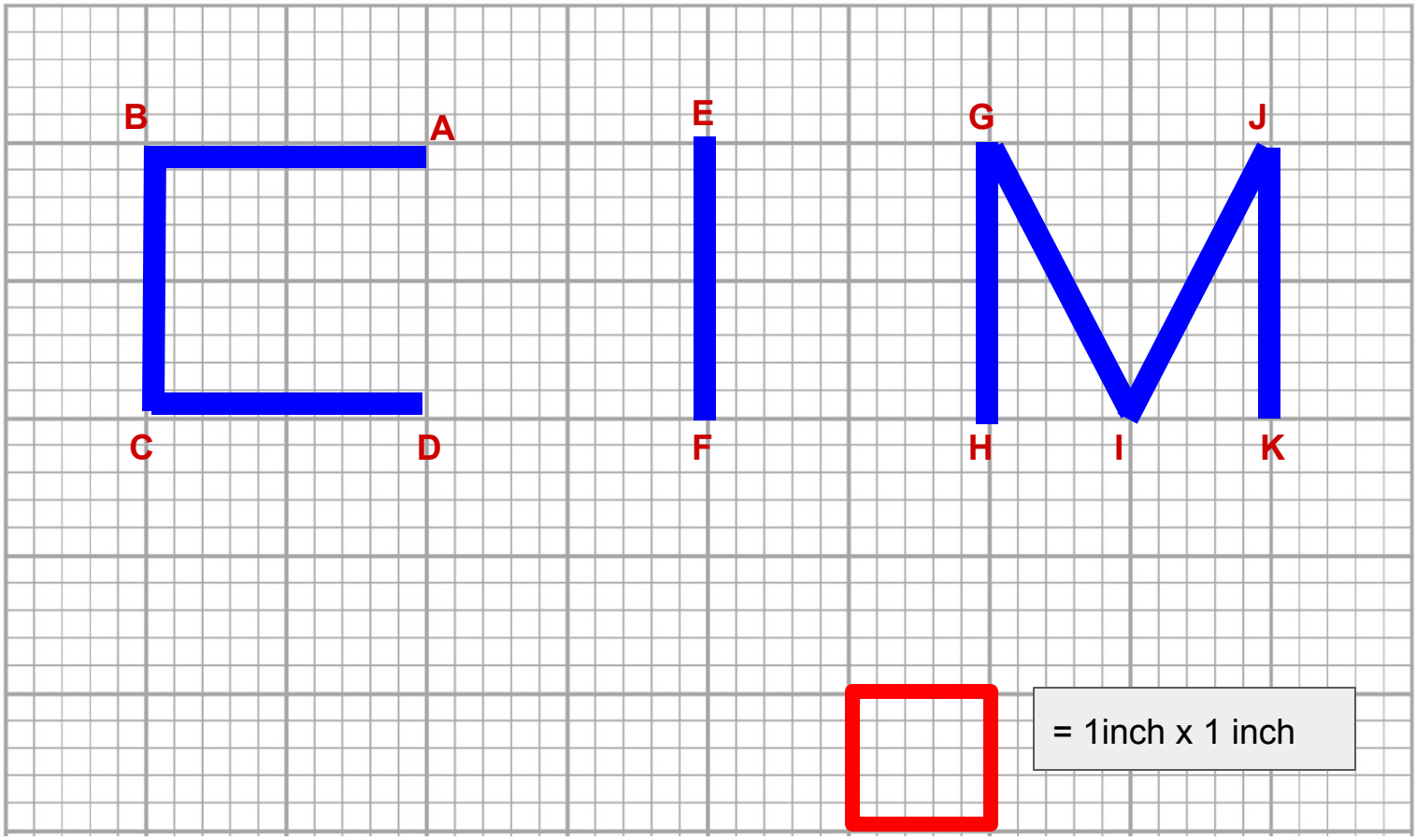
Z Height _____





Tormach ZA6
Movement and Waypoints
Pt 2

13. Adjusting the X, Y, and Z coordinates, create the waypoints to draw C I M for Computer Integrated Manufacturing. Make note when to lift the marker off the table and when to have it in contact.

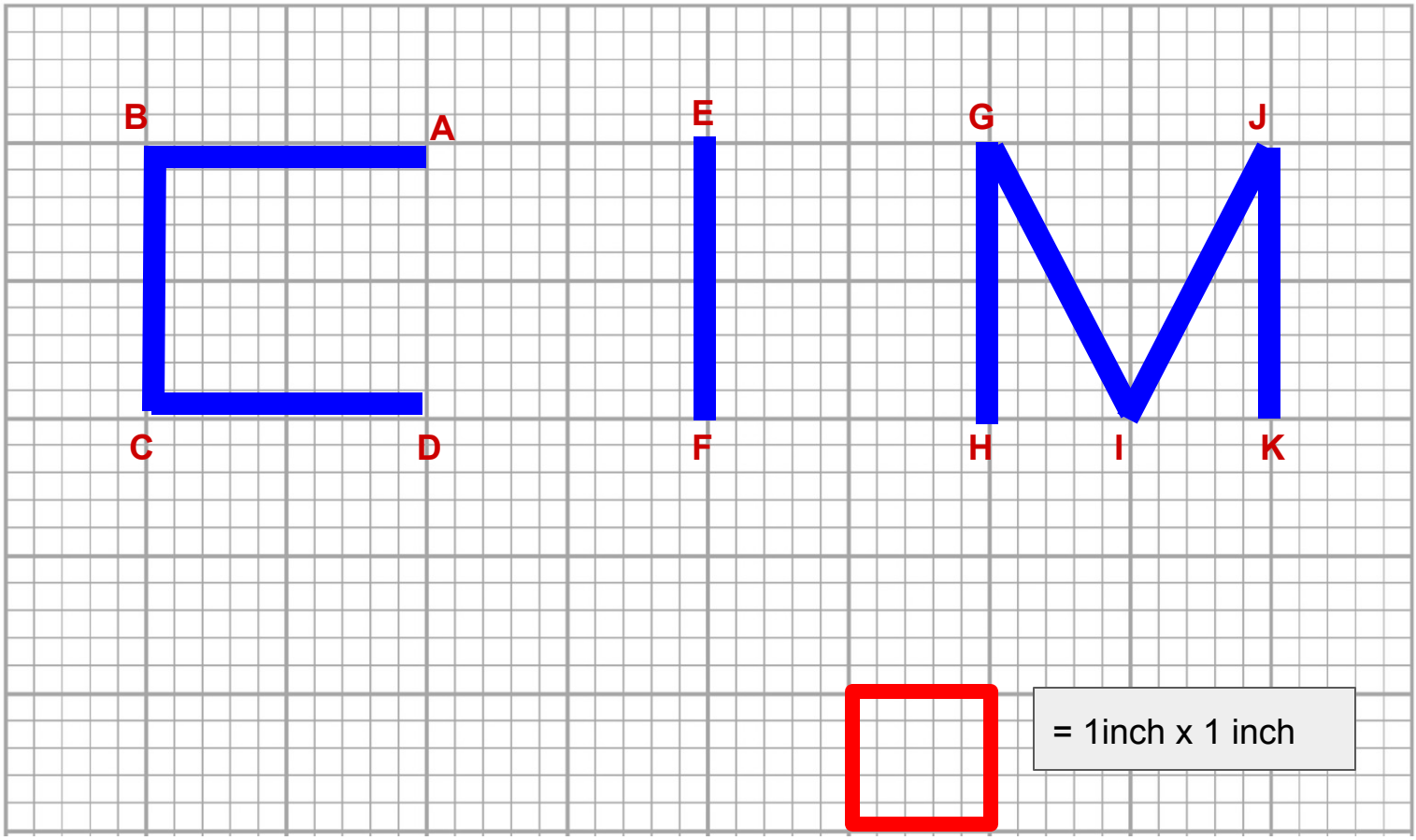


Referring to the XYZ coordinates on the Operation Panel, you can move the robot to a point above point A. Write down the XYZ values you see in the software below

X _____ Y_____ Z _____

Tormach ZA6
Movement and Waypoints
Pt 2

13. Adjusting the X, Y, and Z coordinates, create the waypoints to draw C I M for Computer Integrated Manufacturing. Make note when to lift the marker off the table and when to have it in contact.



Line Segment lengths are as follows:
AB = 2”
BC = 2”
CD = 2”
EF = 2”
GH = 2”
*HI = _____ “
*IJ = _____ ”
JK = 2”

Z Height of Marker tip to whiteboard (from previous page):
_____

Now change those X & Y values to match the values of letter B in the sketch from step 13. Keep in mind that point B is 2 inches in the positive X direction RELATIVE to point A. What are point B’s coordinates? **Leave Z the same!**

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

Tormach ZA6
Movement and Waypoints
Pt 2

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

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

15. Press the Cycle start button and see if it runs through your complete program Correctly. Edit all the points X & Y values until it moves correctly.

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

Tormach ZA6
Movement and Waypoints
Pt 2

Caution: Do not run your program above 30% speed.

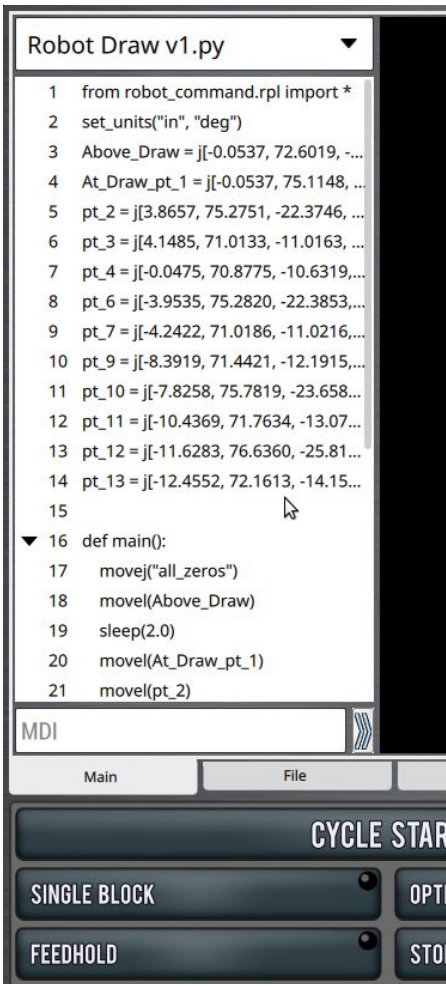
Conclusion

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

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

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

Take a look at the robot code in its PYTHON form. Can you identify the sequence within the code that states the order of steps? Copy and paste it below.

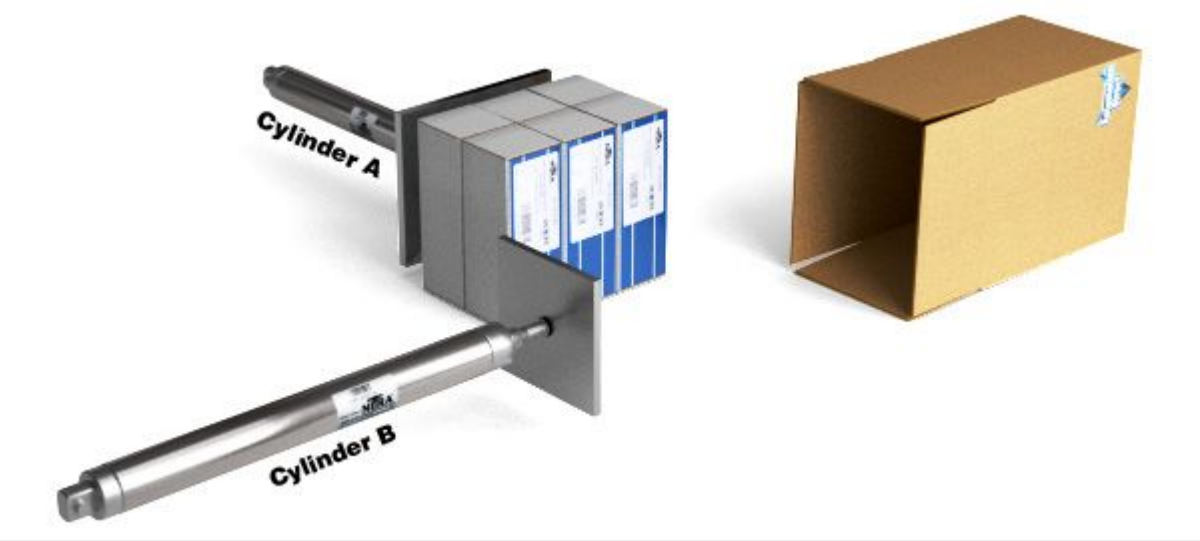


Tormach ZA6 Pneumatics

INTRODUCTION- Why Use Pneumatics?

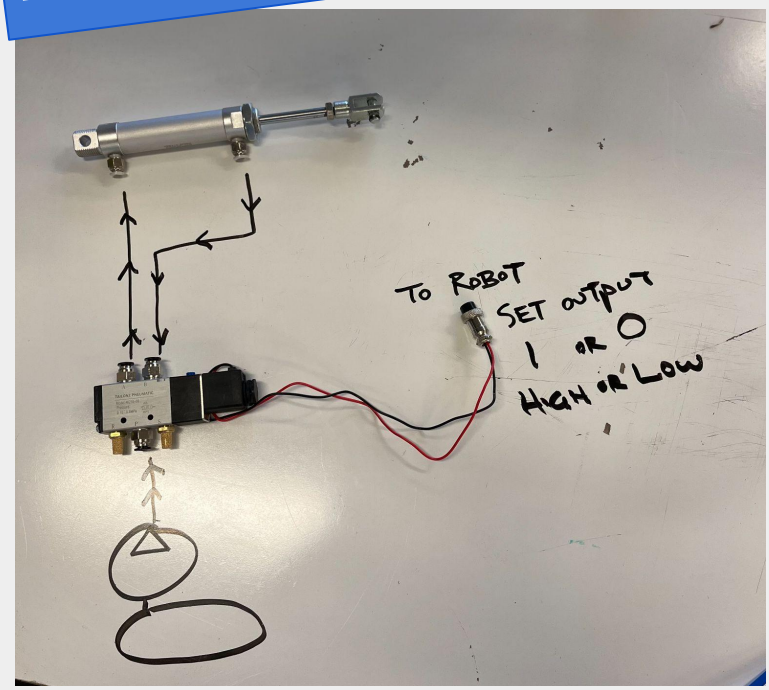
In manufacturing facilities, compressed air is so widely used that it is often regarded as the fourth utility after electricity, natural gas and water. But compared to electricity, compressed air is more expensive, so why is it so widely used to drive factory automation systems?

The main reasons are lower upfront and maintenance costs, which combine to make pneumatics the most popular and cost-effective choice for executing mechanical motion. It's hard to beat the simplicity and reliability of pneumatics.



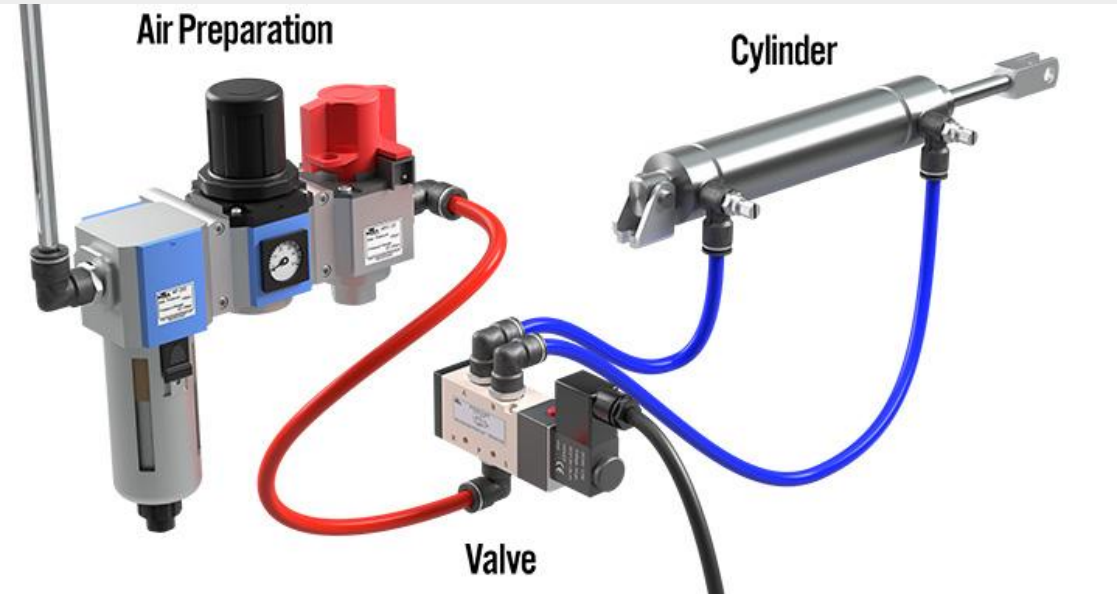
Sequence	Cylinder A	Cylinder B
Position 1	Retract	Retract
Position 2	Extend	Retract
Position 3	Retract	Extend
Position 4	Retract	Retract

Tormach ZA6 Pneumatics

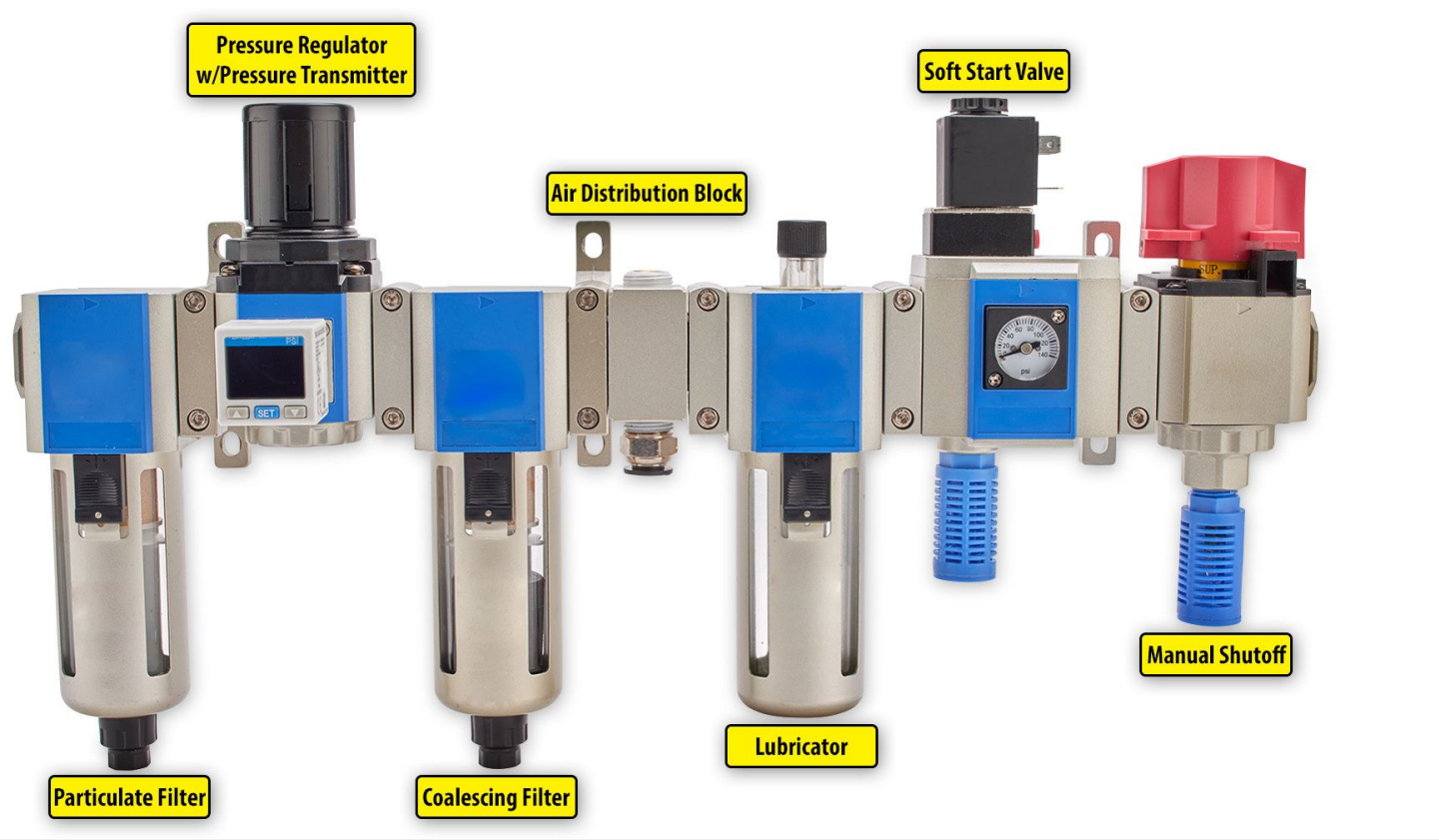


Pneumatic power transmission methods are often the best way to move parts and tooling in industrial machines. These pneumatic systems perform a myriad of tasks in automated equipment such as clamping, gripping, positioning, lifting, pressing, shifting, sorting and stacking.

Some adaptive uses—each of which could include closed loop control for more precise positioning—include tensioning, pressing, labeling, embossing, crimping and cutting.



Tormach ZA6 FRL



All pneumatic systems will have certain basic components. The first is a compressor, and then a system to distribute the clean, dry air it produces.

Common pneumatic components on automated machines include:

- air preparation system (shut-off/lock-out, combination filter/regulator, soft start valve)
- control valves and manifolds (manual, air pilot, solenoid operated)
- air cylinders and actuators
- tubing and hoses
- push-to-connect fittings
- cylinder position sensors
- discrete pressure switches
- specialty components and accessories

The filter, regulator and lubricator (FRL) is installed just downstream of the manual shutoff relief valve. The air filter provides particulate removal and moisture separation filters

Tormach ZA6 Pressure Adjustment

The regulator is selected to match the port size of the upstream filter. It adjusts the pressure of the filtered air between a typical range of 20-130 psi, with lower pressure ranges often available for applications needing more precision. Most piloted valves require 30 psi to operate. Pulling the knob up and rotating it changes the air pressure, and this knob locks in the pressure when pressed down.

1. In a pneumatic system, what generates the energy that powers the system?

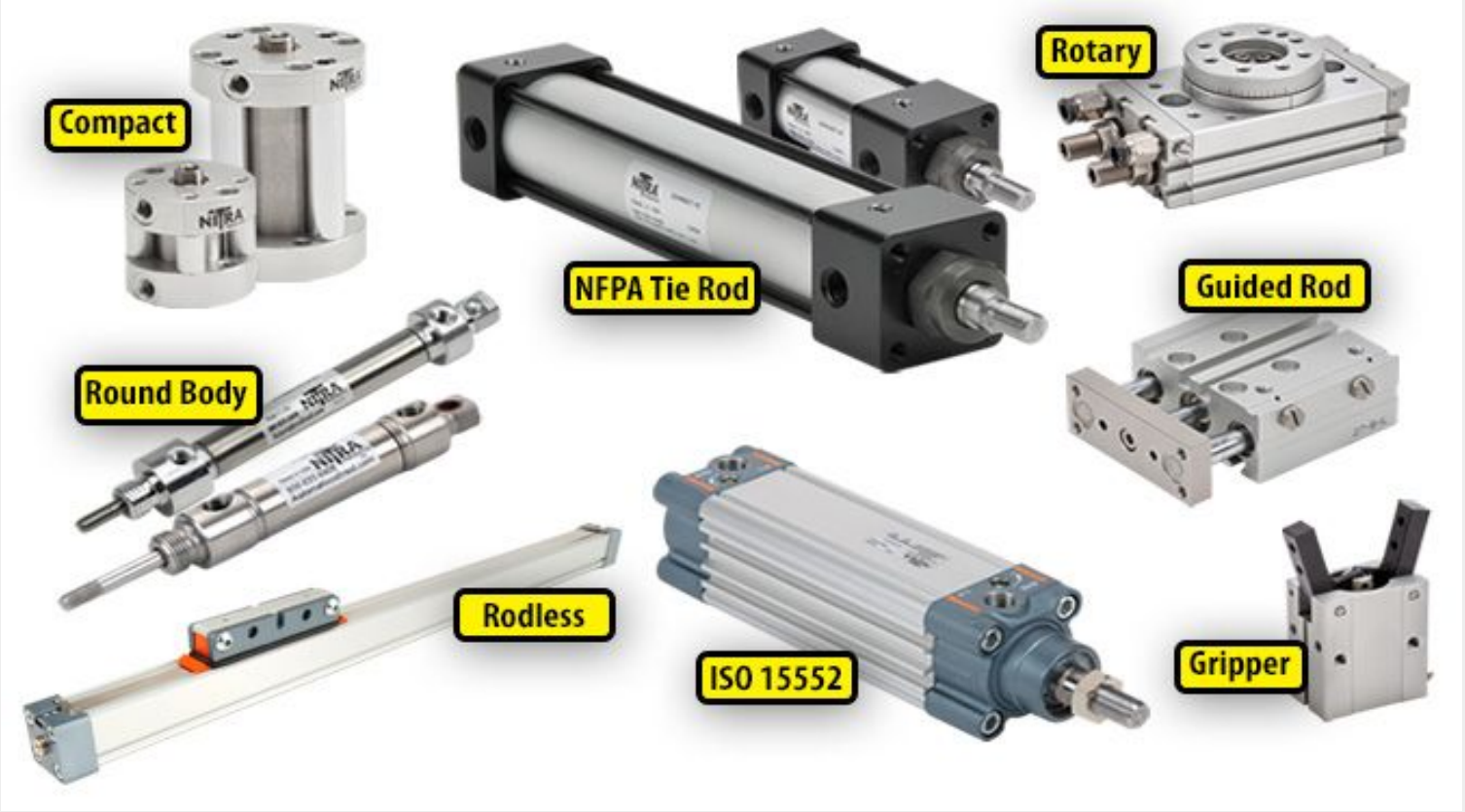
2. What are the 1st two things that need to be done to compressed air in an industrial system?

3. What does FRL stand for?

4. What does the 1st stage in an FLR unit do?

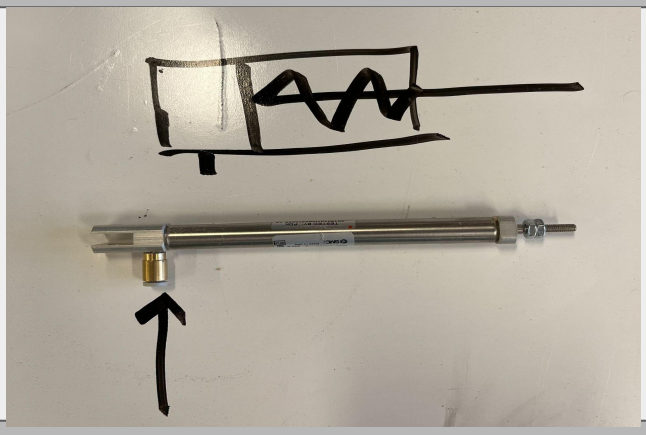
Tormach ZA6
Pneumatic Actuator Basics

There are thousands of industrial applications that require a linear motion during their operation sequence. One of the simplest and most cost effective ways to accomplish this is with a pneumatic actuator. Pneumatic actuators are also very clean operating because the operating fluid is a gas, which prevents leakage from dripping and contaminating the surroundings.

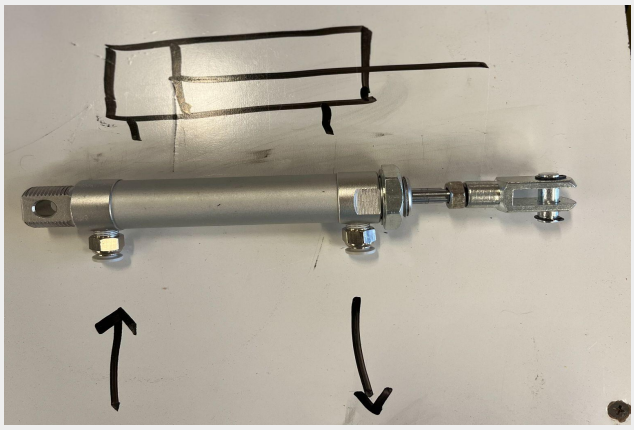


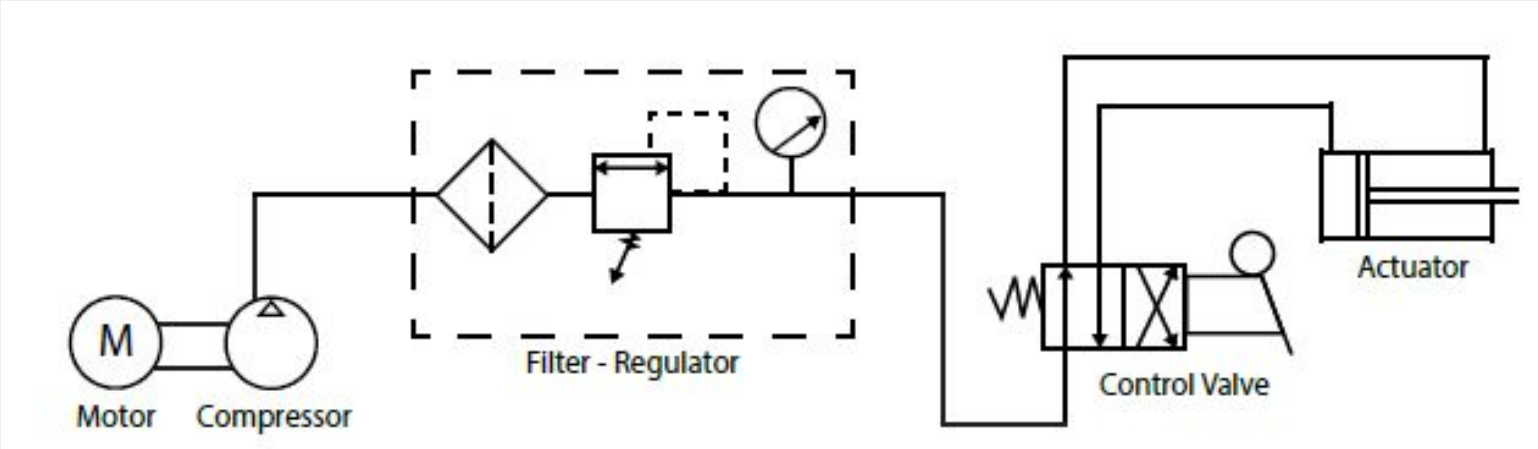
Tormach ZA6 Single Acting Pneumatic Actuator

Single-acting cylinders have a single port to allow compressed air to enter the cylinder to move the piston to the desired position. They use an internal spring or sometimes simply gravity to return the piston to the “home” position when the air pressure is removed. Single-acting cylinders are a good choice when work is done only in one direction such as lifting an object or pressing an object into another object.



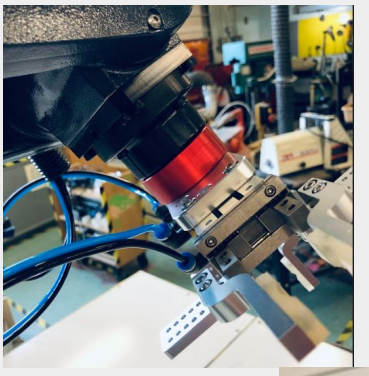
Double-acting cylinders have a port at each end and move the piston forward and back by alternating the port that receives the high pressure air. This uses about twice as much energy as a single-acting cylinder, but is necessary when a load must be moved in both directions such as opening and closing a gate.

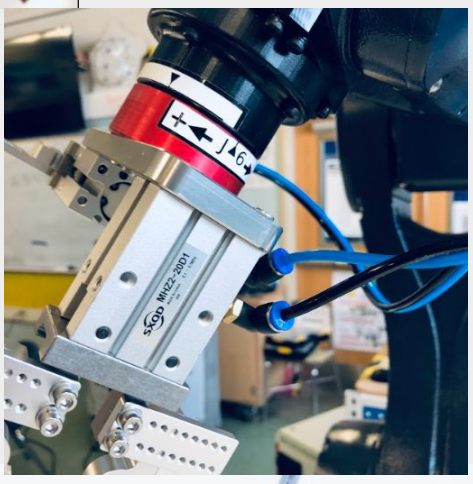


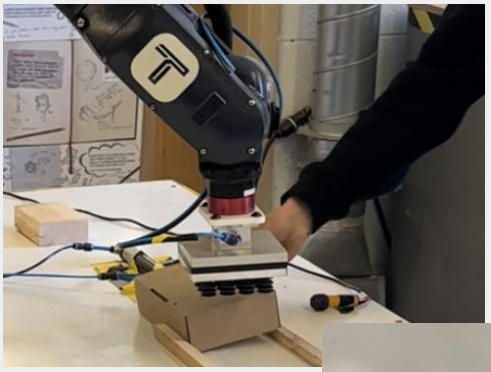


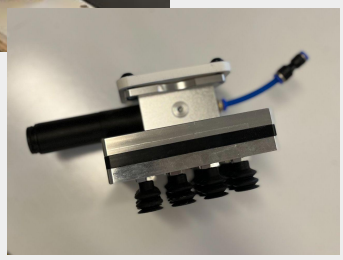
Tormach ZA6 Grippers and Vacuum Devices

The end effector that picks up the object in a pick-and-place system can be pneumatic grippers or vacuum suction cups both of which are usually lighter, smaller and less expensive than electric grippers.









5. How many ports does a double acting actuator have?

Tormach ZA6 Valves

In the pneumatic world, valves are the equivalent of relays controlling the flow of electricity in automation systems. Instead of distributing electric power to motors, drives and other devices, pneumatic valves distribute air to cylinders, actuators and nozzles.

Manually activated valves are typically switched open and closed by a foot pedal, toggle actuator, handle, knob or push button. An operator controls the activated position of the valve, and a spring or the operator returns the valve to its home position.

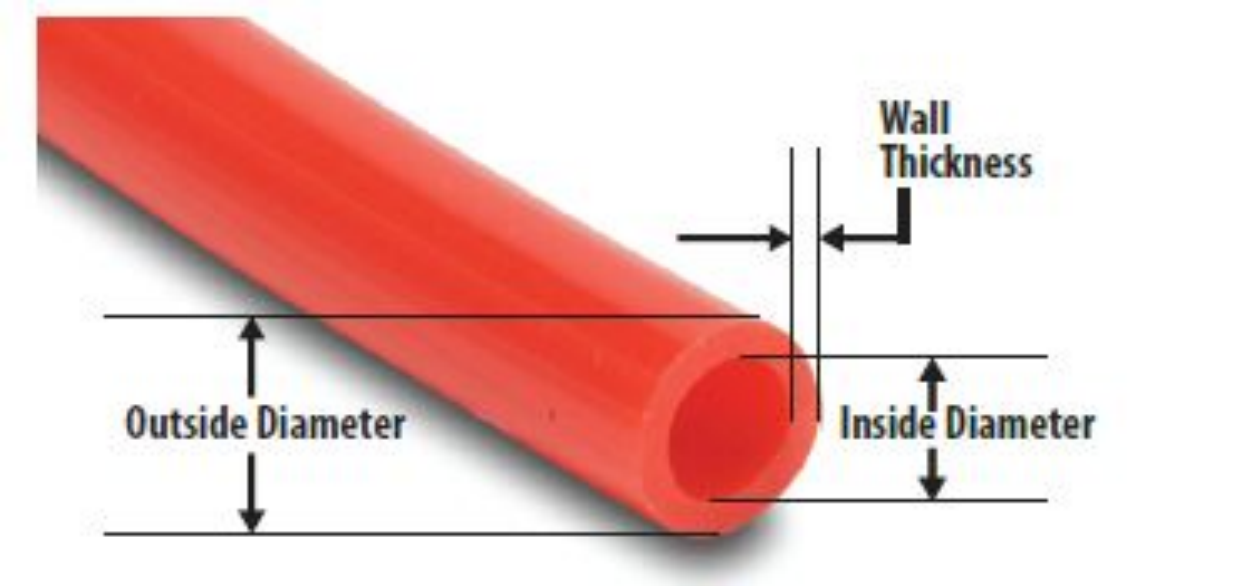
Solenoid operated valves use an electrical coil to control the position of a poppet, plunger or spool to open or close a valve. Typical solenoid control voltages are 12VDC, 24 VAC/DC, 120VAC or 240VAC.

Air piloted valves are operated by an external air source such as a solenoid operated valve in a remote location. The valve can also be internally air piloted, enabling use of a smaller integrated electric solenoid to provide an air pilot signal to control the larger valve spool.

Tormach ZA6 Plumbing Methods

A variety of threaded ports or push-to-connect fittings are available to attach pneumatic tubing to valves.

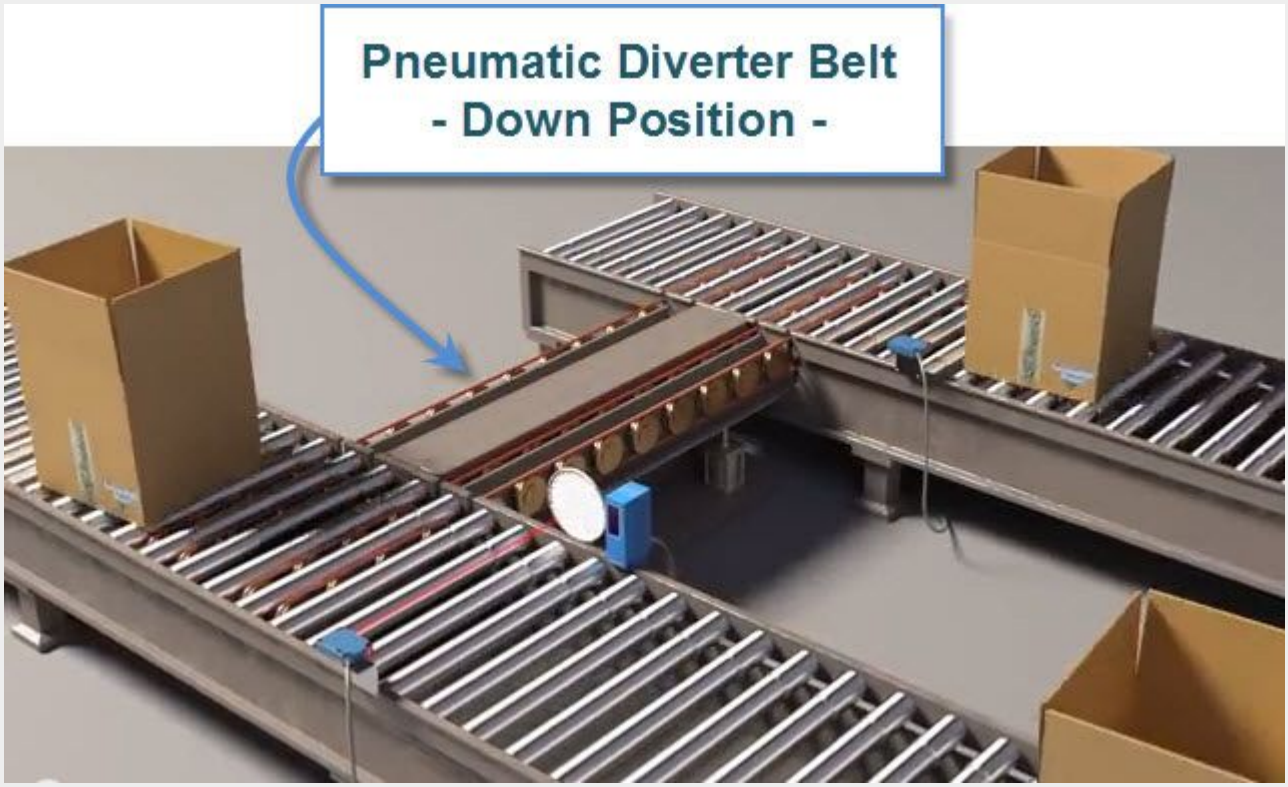
Tubing and Hose
Flexible tubing is the most common way to connect pneumatic valves to cylinders, actuators and vacuum generators in modern automated equipment, with hose a close second. With any type of tubing be careful to not confuse outside diameter (OD) with inside diameter (ID), and be aware that flexible and rigid tubing are two different types of materials.



Tubing is specified by the outside diameter (OD) and hose is by the inside diameter (ID)

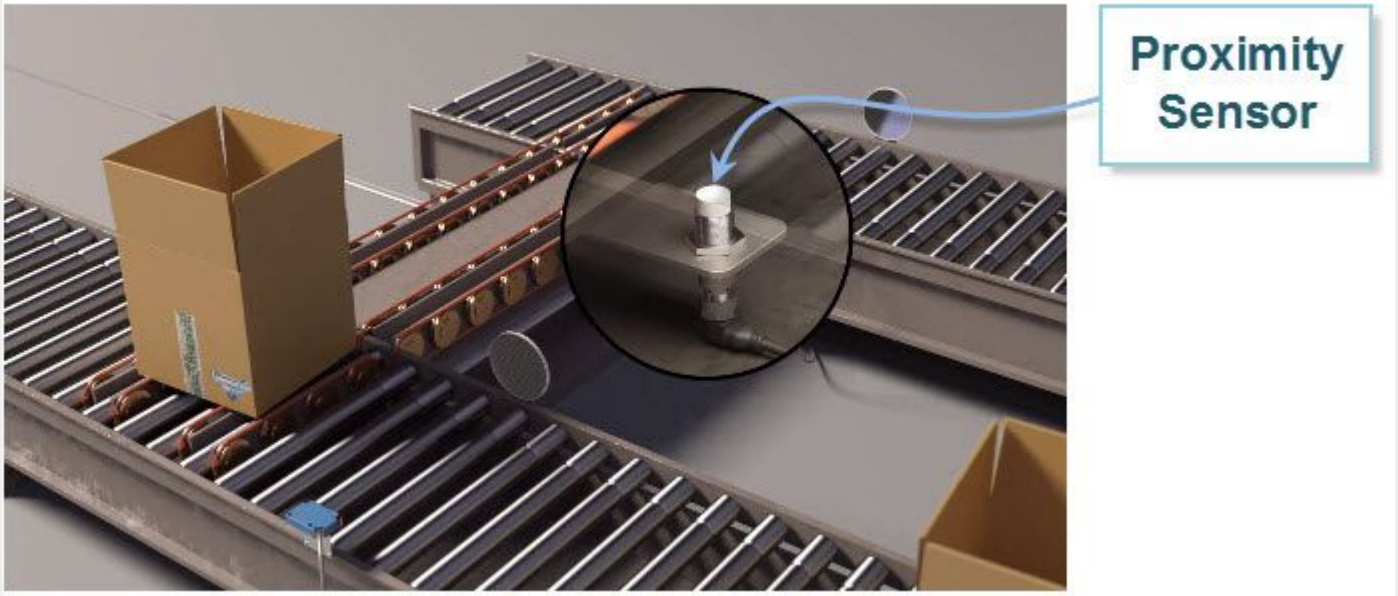
6. What type of valve would you choose to connect directly to the robot controller on the ZA6 robot?

Tormach ZA6
Application Example

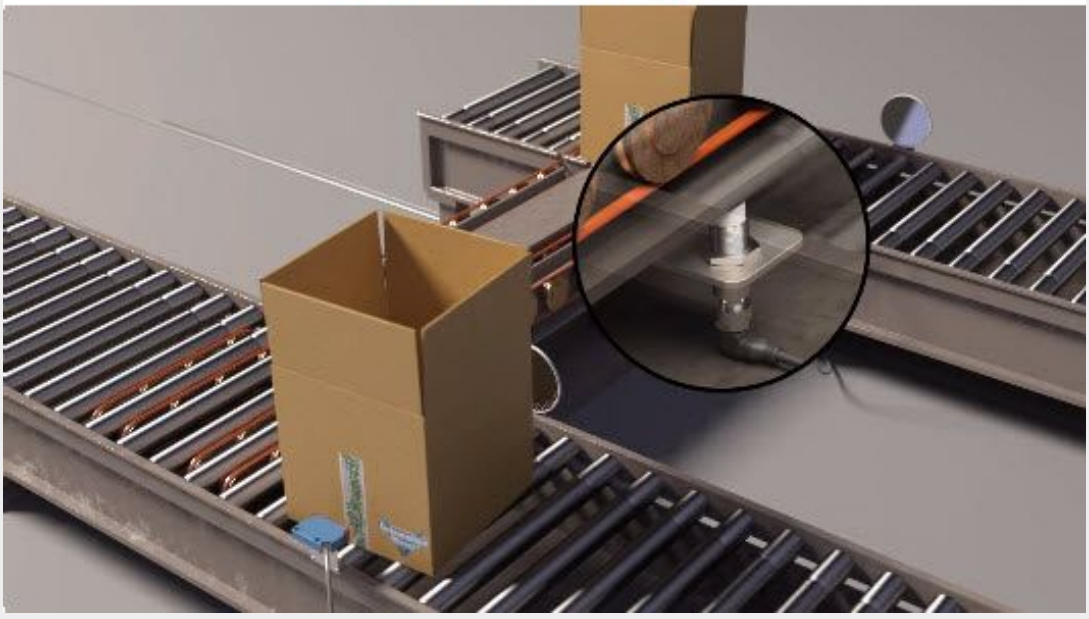


Tormach ZA6
Application Example with Sensor

UP Position

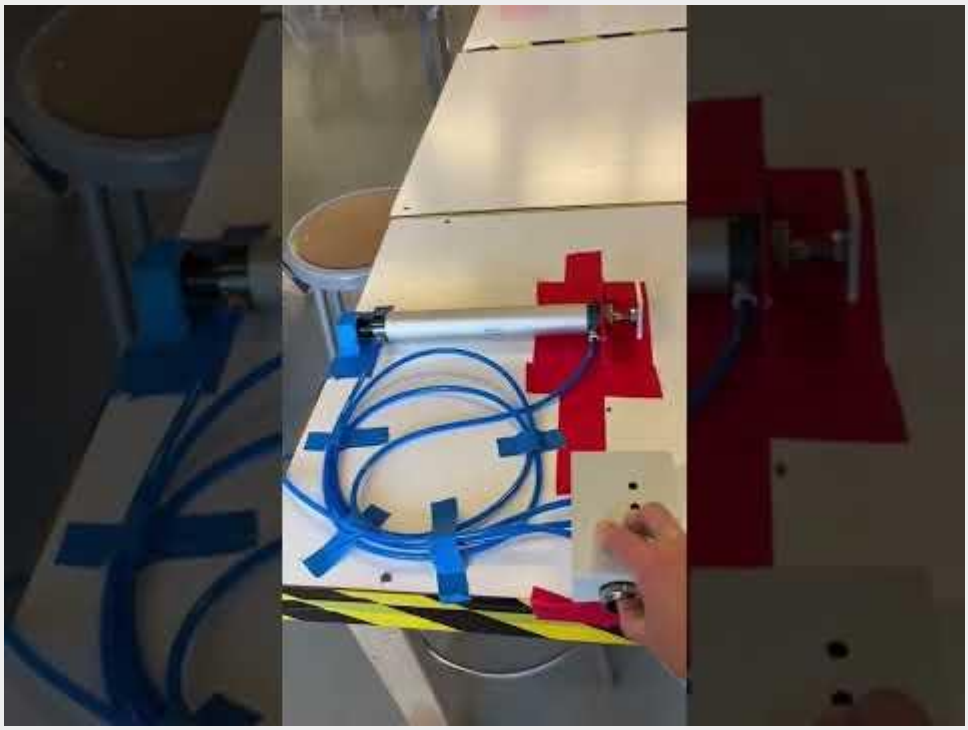


DOWN Position

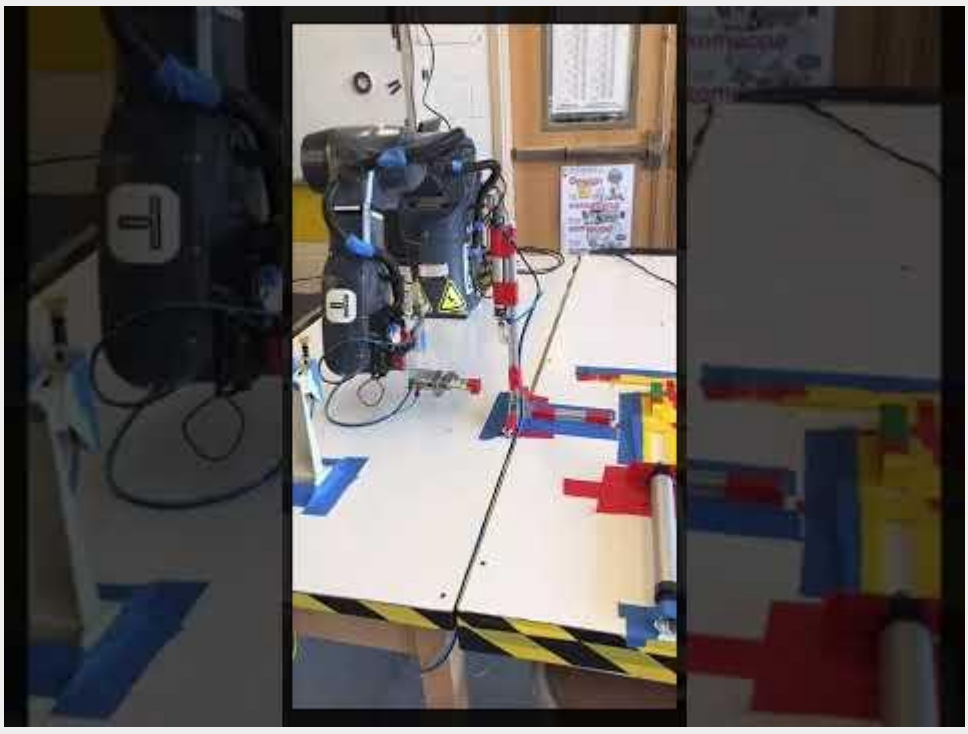


Tormach ZA6
Application Example with Sensor

Video Clip
Click on Picture



Video Clip
Click on Picture



Tormach ZA6
Hands-on Practice

7. Design a system with the Tormach ZA6 to move material using a pneumatic actuator and picking or placing the material with the robot. Draw the initial layout below. In the drawing, include the compressor, valve, and actuator as well as the robot end of arm tooling.

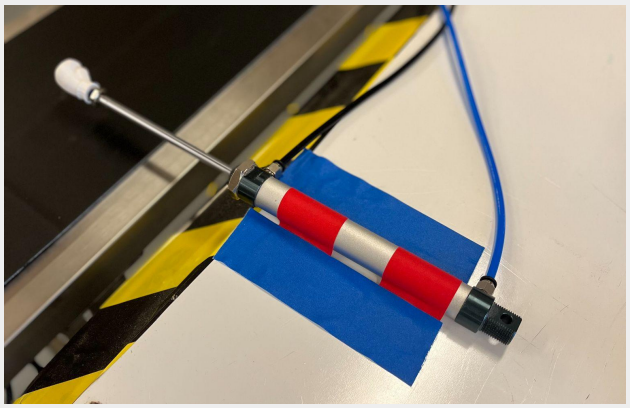
8. Fill in the below sequencing chart :

Sequence	Cylinder	Robot
Position 1		
Position 2		
Position 3		
Position 4		
Position 5		
Position 6		
Position 7		
Position 8		
Position 9		
Position 10		

Tormach ZA6
Hands-on Practice

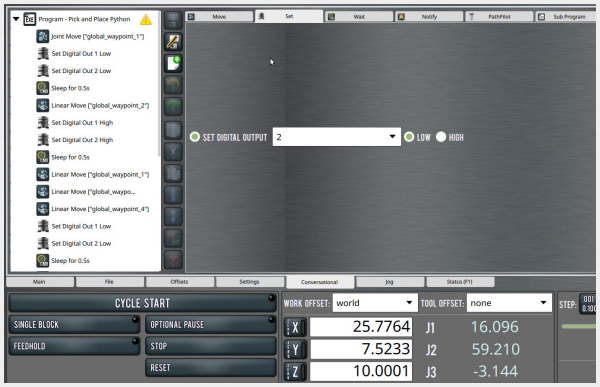
9. Create the robot system. With your instructors assistance, attach all necessary components to the work surface and the ZA6. Often times masking tape to secure the actuators to the table to strong enough for a temporary design.

_____Instructors initial when complete



10. Create your robot program. Refer to the previous skill builders as a refresher as you create your robot program. Have your instructor check your work and initial below BEFORE you run your program.

_____Instructors initial when complete



Tormach ZA6 Pneumatics

CONCLUSION

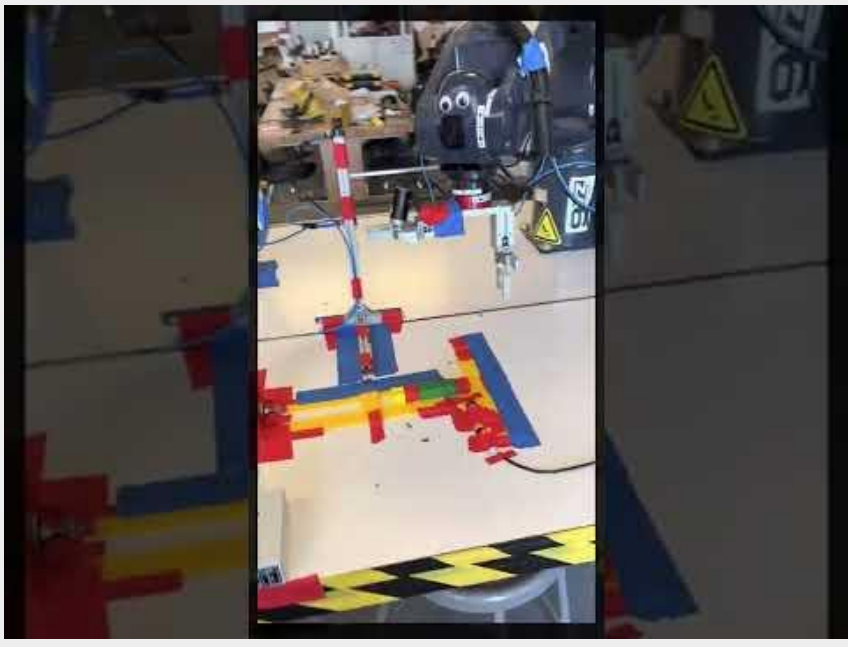
1.What are the five components that make up a fluid power system?

2. What is used in a pneumatic system to tell the air where to go?

3. How many working ports on a control valve are open at one time?

4. What is the final component that allows use to do useful work with our compressed air?

Video Clip
Click on Picture



GOING BEYOND

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

_____ 1. Design a system which utilizes a pneumatic actuator and a sensor to tell the robot what material has been moved

_____2. Plumb a system that controls 2 pneumatic actuators from a single solenoid (hint: refer to plumbing methods)

Tormach ZA6 Inputs & Sensors

Video Clip
Click on Picture

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

Tormach ZA6
Inputs & Sensors

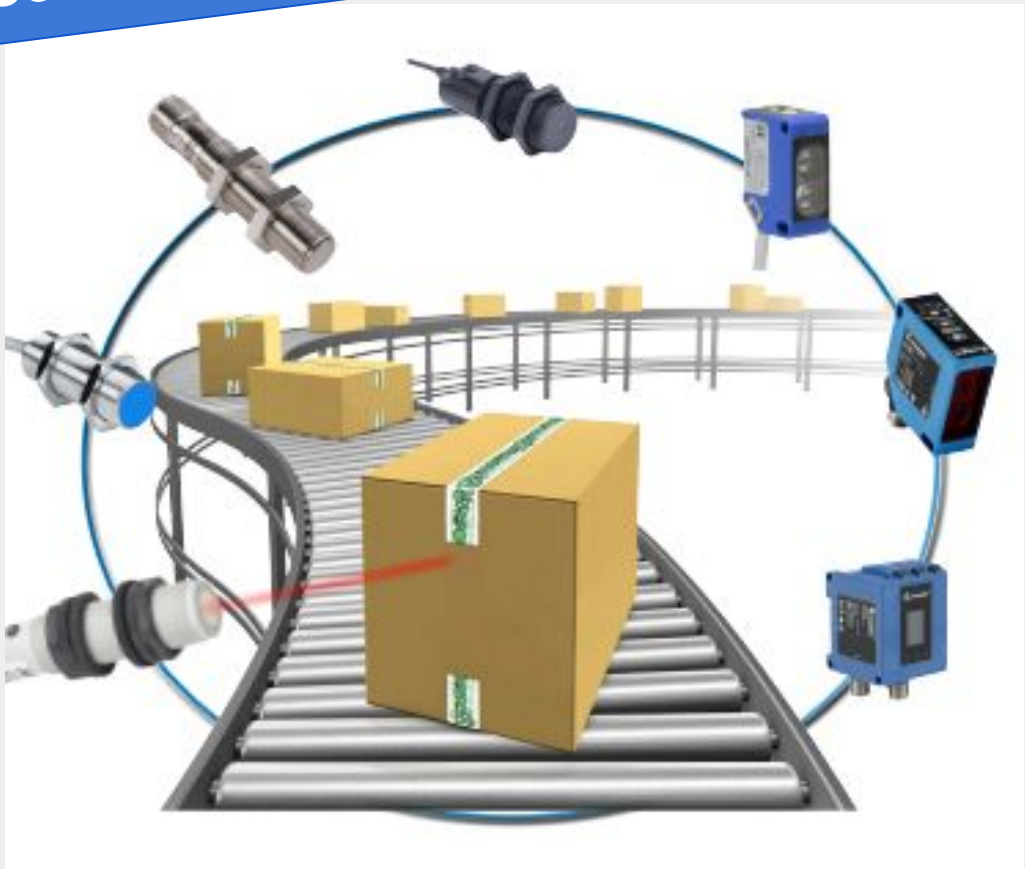
Key Vocabulary

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

Equipment & Supplies

- Tormach ZA6
- Path Pilot Software
- Pneumatic Gripper or Suction Cup
- Input Devices
- Output Devices (pneumatic actuators)
- Manipulatable material (Cardboard Boxes, Wood Cube, etc..)

Tormach ZA6
Inputs and Sensors

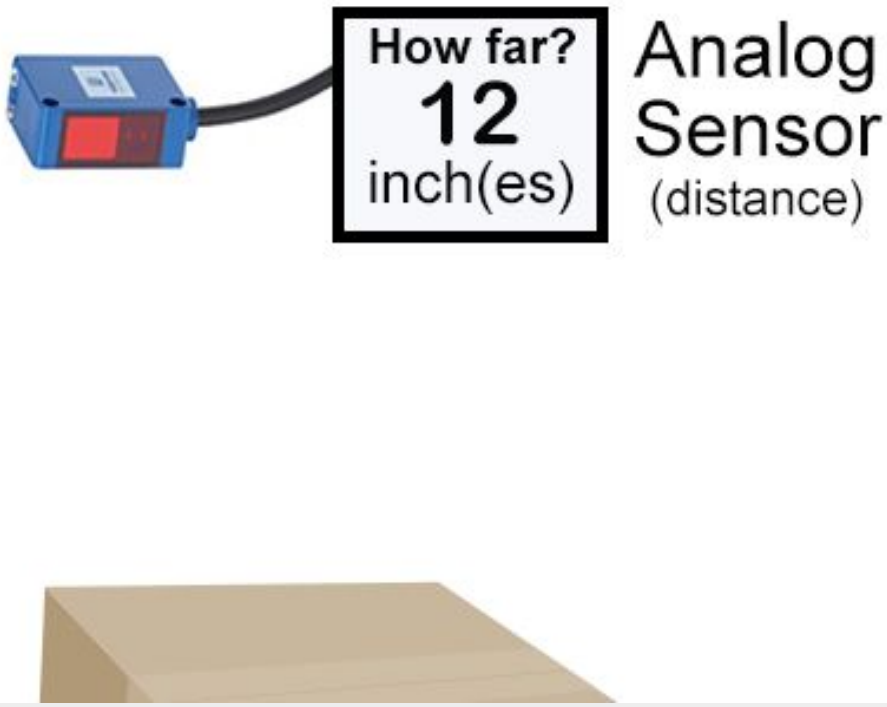


What Type of Sensor Do I Need?

There are many factors that will determine the “best” sensor to use for a given application. Experience is the best teacher when it comes to selecting sensors. However, there are a few questions that can be asked to help narrow down your selection to a sensor type.

With careful review of the specifications for the different sensor technologies, it will be clear that there is much overlap in sensor applications. However, with a closer look you will find that some technologies work better for particular applications. For example, if your target is metal, such as on a pneumatic or motor driven actuator, start with an inductive proximity sensor. Photoelectric sensors are a good starting place when detecting pallets and boxes on a conveyor and other part sensing applications. If you need to monitor tank levels, capacitive proximity sensors or ultrasonic senors are usually your best bet.

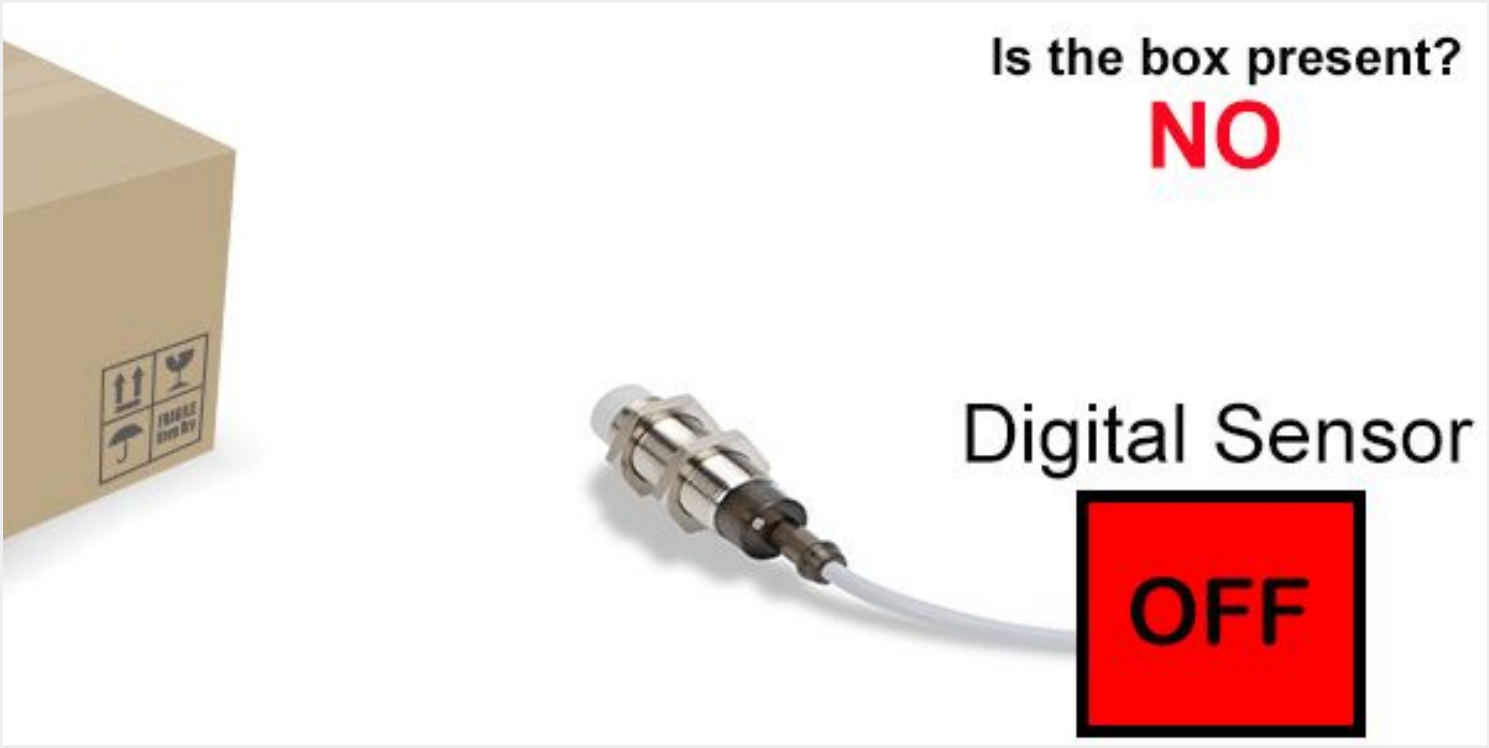
Tormach ZA6
Inputs and Sensors



Analog Sensors vs. Digital Sensors
The output generated from sensors can be either analog signals or digital signals.

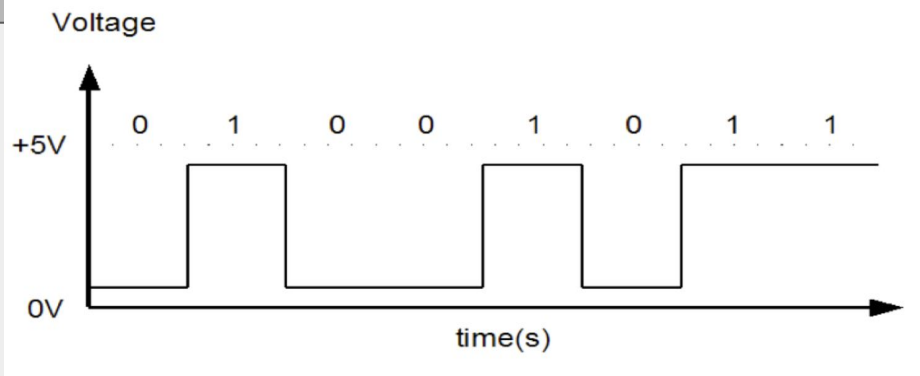
Analog Sensors
Analog Sensors output a change in electrical property to signify a change in its environment. The change can be a variation in Voltage, Current, Resistance, Charge and Capacitance. Sensor circuits are designed to monitor these changes and provide a voltage difference.

Tormach ZA6
Inputs and Sensors



Digital Sensors
Unlike Analog sensors, digital sensors produce discrete digital pulses for a change in its environment. A push button switch is a very good example of a digital sensor. The output of this sensor can be either “ON” or “OFF”, i.e. it can be either 1 or 0.

There are other digital sensors which output a series of digital pulses, or binary values. For example, a sensor can output a 10 bit binary value 0000000000 to 1111111111 (decimal equivalent of 0 to 1023) to signify a change. This means a sensor can produce one of 1024 values to suggest a change in its environment.



Tormach ZA6
Inputs and Sensors

Photoelectric Sensors

Photoelectric sensors use light and optics to detect object presence or distance. They provide an output based on object detection or distance criteria. Photoelectric sensors can detect a wide variety of materials and measure distances from a few millimeters up to 100 meters.

Inductive Proximity Sensors

Proximity sensors detect the presence of metallic objects at close range (up to 1.5 inches typically). Ferrous metals allow the greatest distances to the sensor; other metals may reduce detection range. Low-cost, reliable sensors are available in an array of shapes and sizes for a wide range of applications

Mechanical Switches

Limit switches are one of the most common object detection sensors used in industrial controls. They are energized when an object makes physical contact with the actuator. They normally provide an electromechanical contact closure, but some also move a pneumatic valve. There are many different form factors and actuator styles to choose from.

Tormach ZA6 Workcell Design

-Video Clip-
Click on Picture

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.

Tormach ZA6 Workcell Design

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!

Tormach ZA6
Inputs and Sensors

CONCLUSION

1. What does it mean that the switch is DIGITAL?

2.What type of operation could this be simulating?

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

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

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

6. What are the inputs you used in your workcell?

7. What are the outputs you used in your workcell?

8. Explain how nesting parts is important in any manufacturing process.

Tormach ZA6
Inputs and Sensors

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

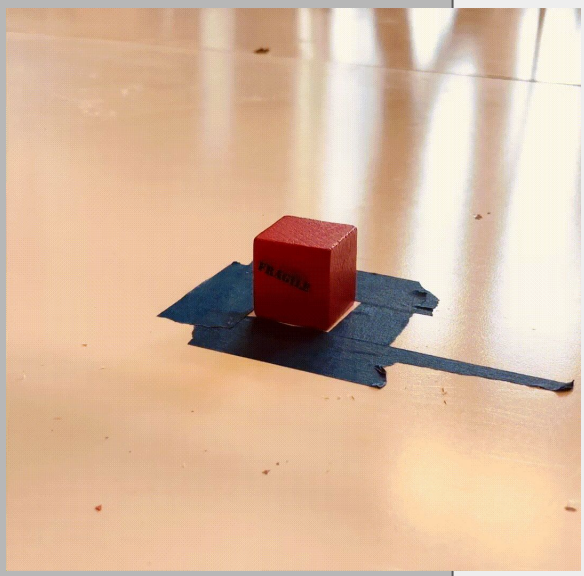
Tormach ZA6 Pick and Place

Video Clip
Click on Picture

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



Tormach ZA6 Pick and Place

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 ZA6?
- How do I **record** positions (waypoints) with the ZA6?
- How do I easily edit a program in Path Pilot Robot Edition?

KEY VOCABULARY

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

EQUIPMENT & SUPPLIES

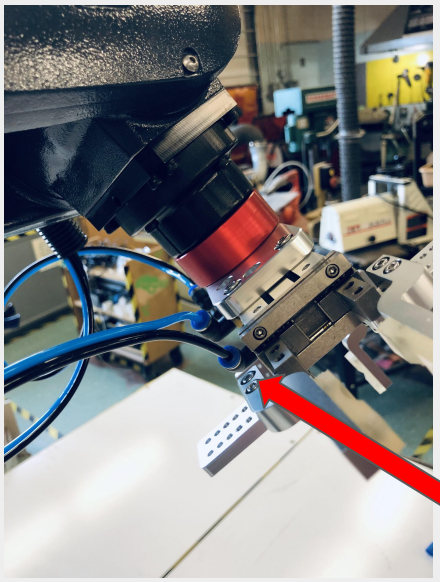
ZA6 Robotic Arm
ZA6 White Board Field Diagram
¾ inch cylinders
¾ inch cubes
Pneumatic Gripper
Path Pilot software

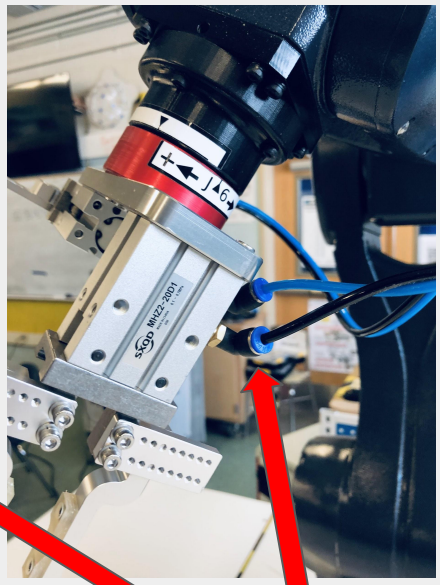
Tormach ZA6 Pick and Place

PROCEDURE

Caution: NEVER wire anything to the ZA6 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 at the end of the robot, and plug in the pneumatic lines as shown below. Connect the Solenoid valves to I/O 1 and I/O 2

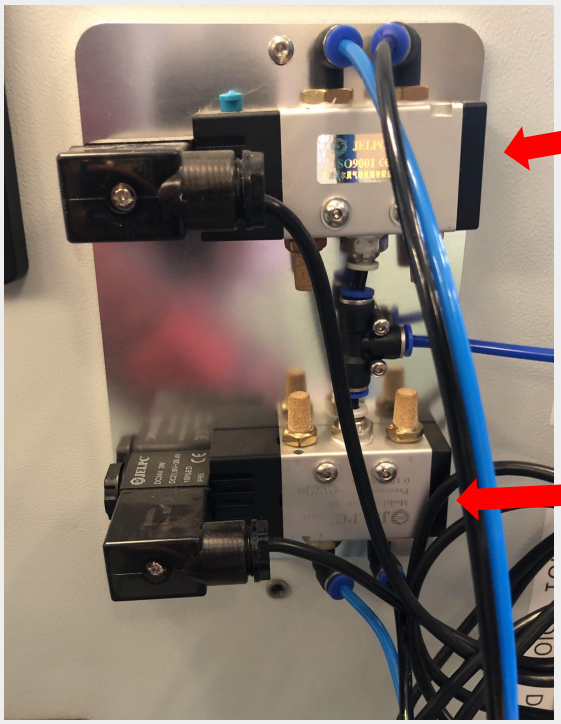




Push to connect air fittings

Air lines should be run along the arm and secured in sheathing

Tormach ZA6 Pick and Place

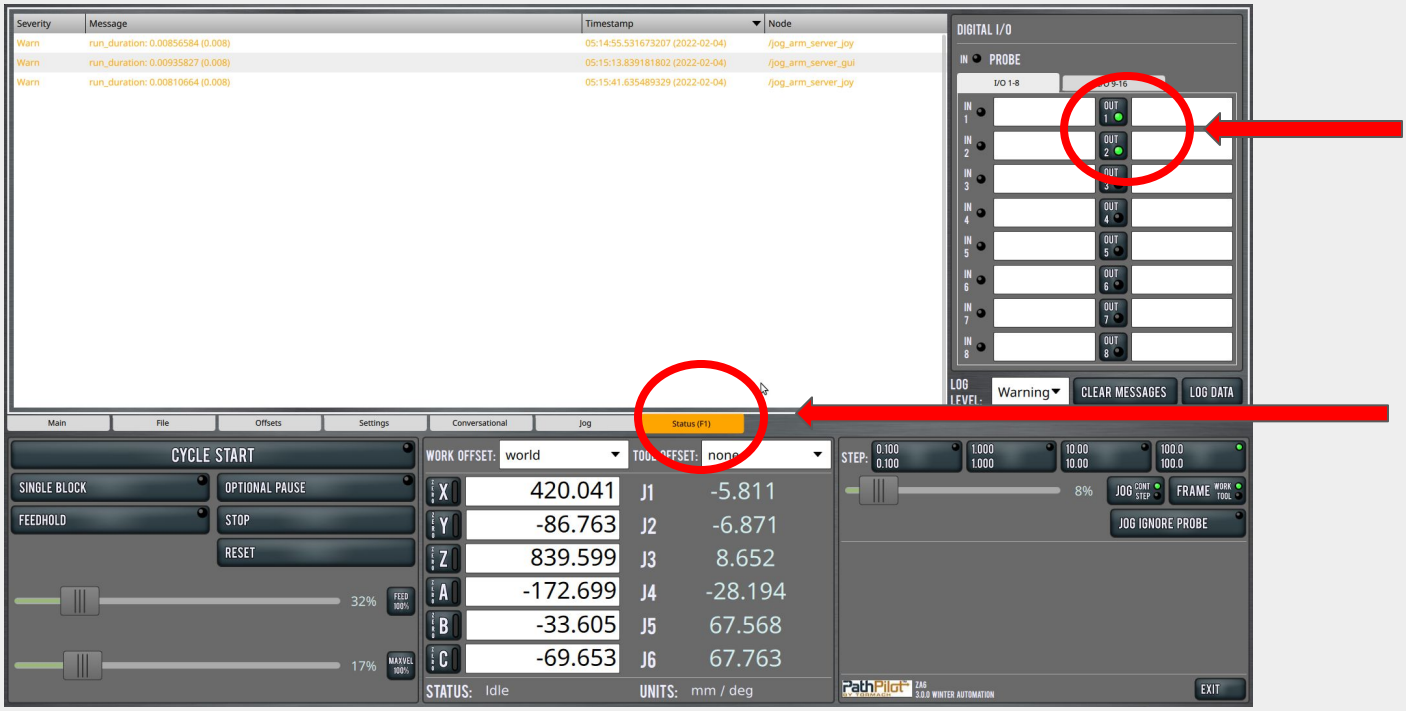


A solenoid is an electronically controlled switch. These solenoids operate on 24 volts DC. They are used to control the air flow to the end of arm tooling.

Each solenoid should be connected to an Input/ Output connection (I/O). The Path Pilot Controls can send or receive a signal from these ports.

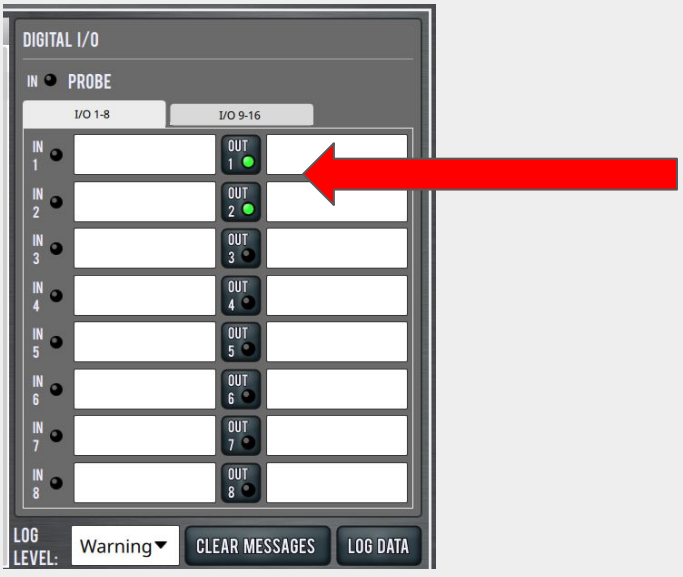
Tormach ZA6 Pick and Place

2. Open Path Pilot Robot Edition software and connect the robot. Navigate to the STATUS tab and locate the outputs to the right.



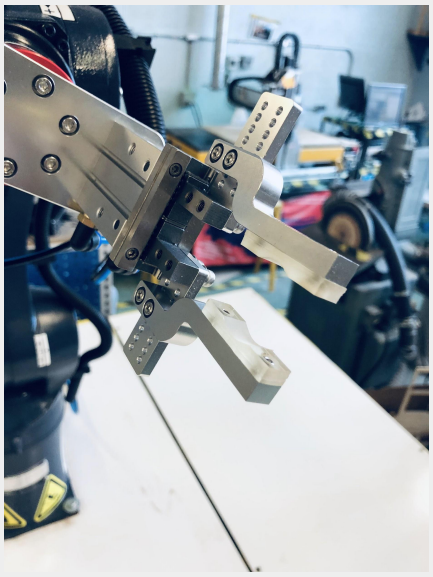
Check your connections to the gripper by toggling on OUTput 1 and OUTput2.

If the green light is on the OUTput would be set to HIGH. If the green light is off the OUTput would be set to LOW.



Tormach ZA6 Pick and Place

On the back of the robot controller you should see the solenoid switch light correspond with the light icon in the STATUS tab.



Record below the results from the test (circle your answer):

OUT 1 HIGH (Green light on)

Gripper closed/ Gripper open

OUT 1 LOW (Green light off)

Gripper closed/ Gripper open

OUT 2 HIGH (Green light on)

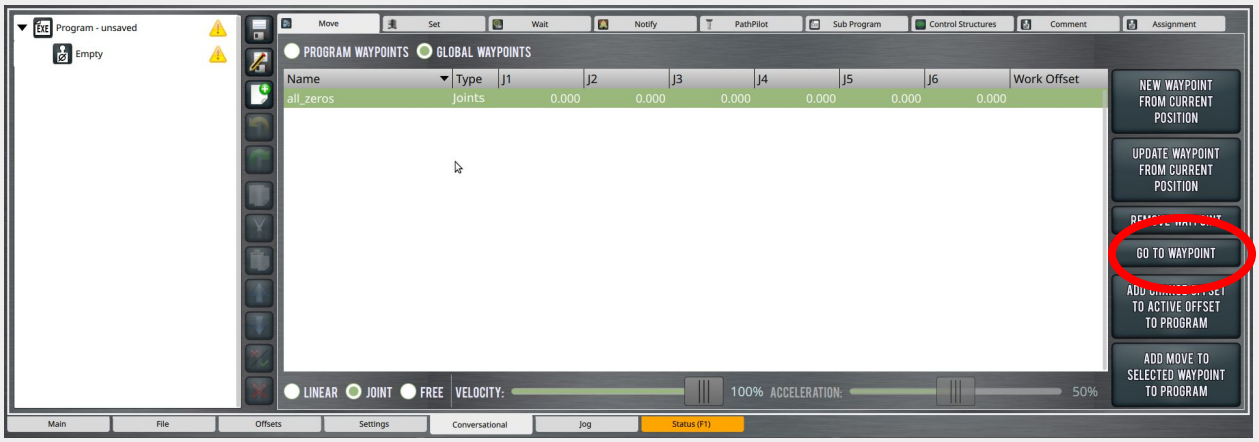
Gripper closed/ Gripper open

OUT 2 LOW (Green light off)

Gripper closed/ Gripper open

Tormach ZA6 Pick and Place

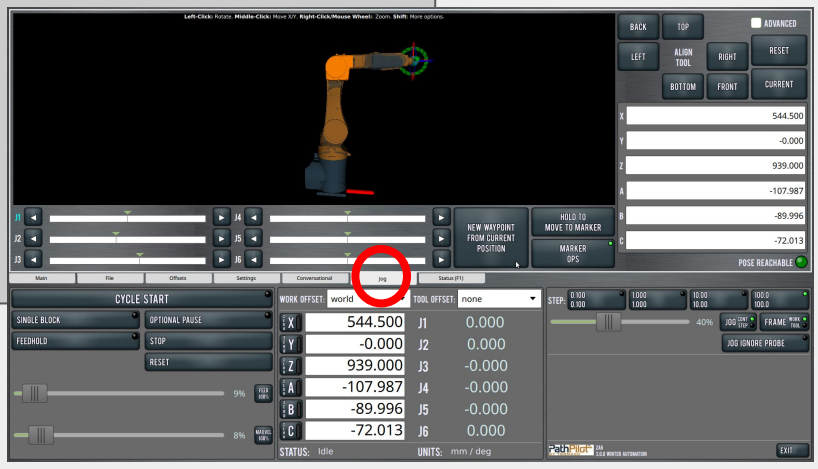
3. Bring the robot to **Global Waypoint all_zeros** making sure the robot's work envelope is clear.



4. Place one of the ¾" wooden cylinders on one of the squares of the field diagram and mark its location. You will be using this as a reference, but you will first be running the machine without any obstacles.

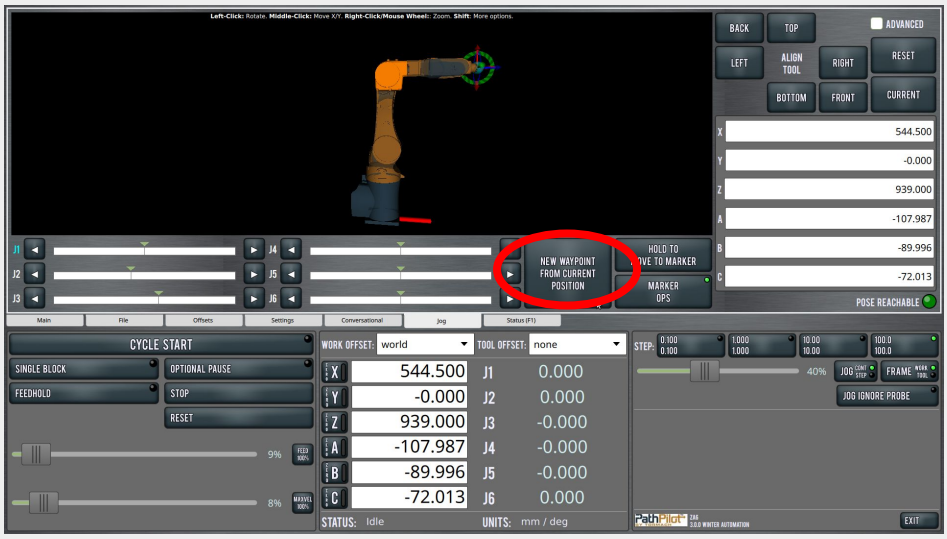
5. Use the **Jog** tab in Path Pilot to record all the positions necessary waypoints to do a pick and place operation. Name the positions of the program under the waypoint name.

- Home
  (or safe location of your choosing)
- Above Pick
- At Pick

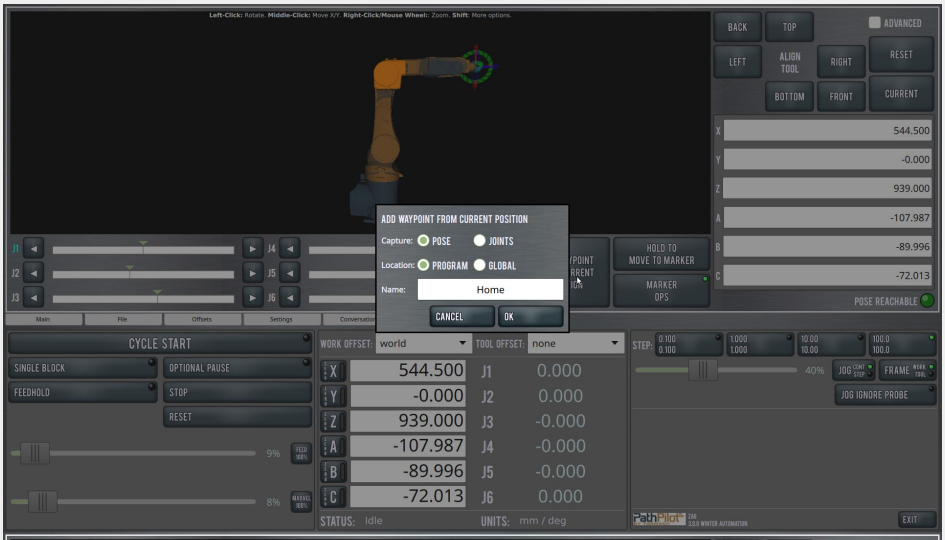


Tormach ZA6 Pick and Place

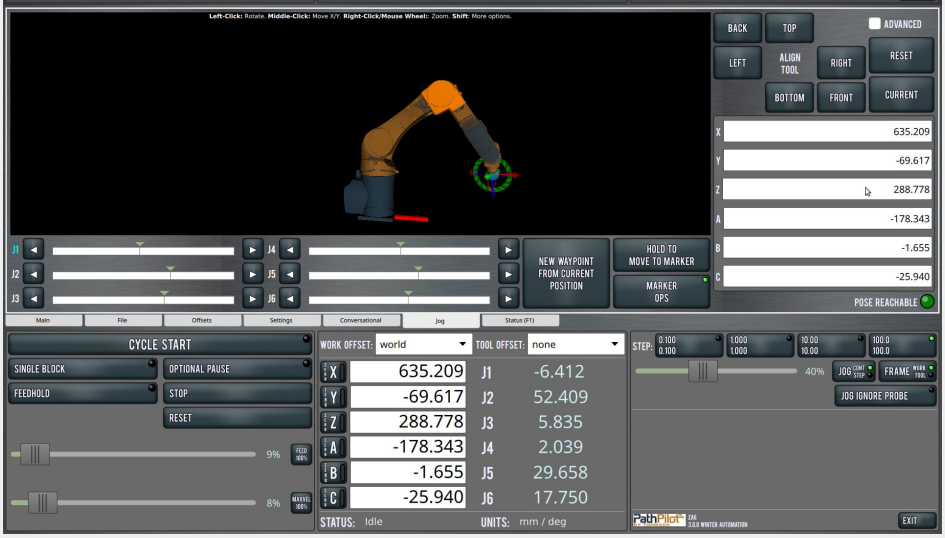
Jog to a Home Position



New Waypoint From Current Position

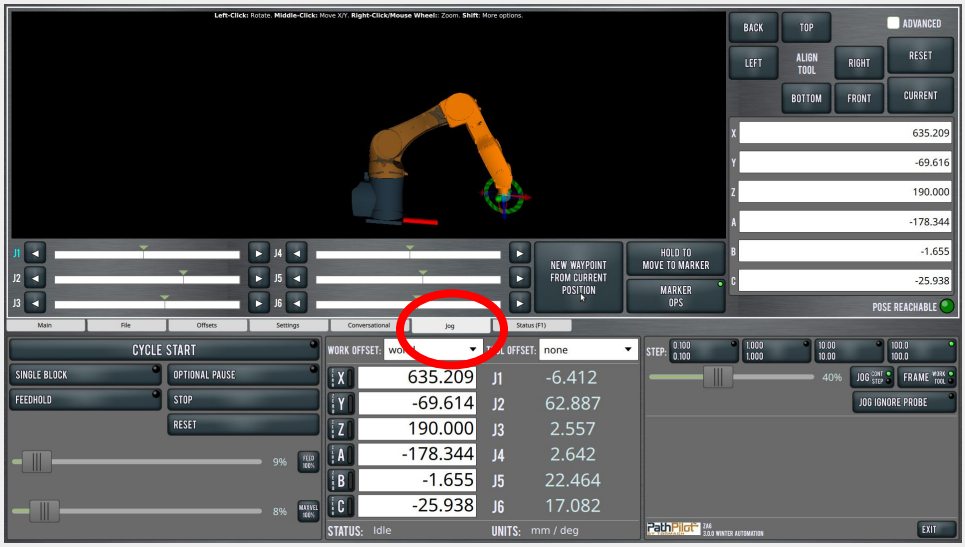


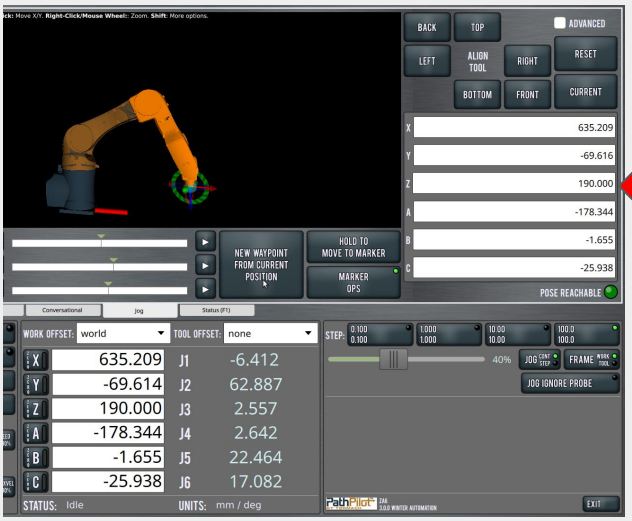
Jog to Above Pick



Tormach ZA6 Pick and Place

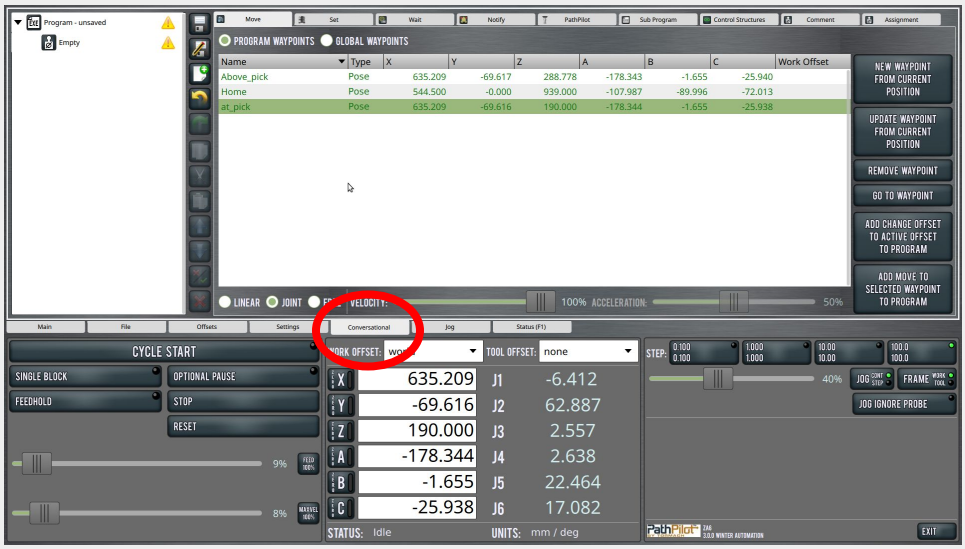
Jog to At-Pick





Quick TIP:
When moving from Above Pick to At Pick adjust your Z coordinate in Jog mode. This will keep the gripper orientation lined up with your part. Move the Z coordinates in small increments to avoid accidental collisions (recommended subtracting 10 mm and checking by Hold to Move to Marker).

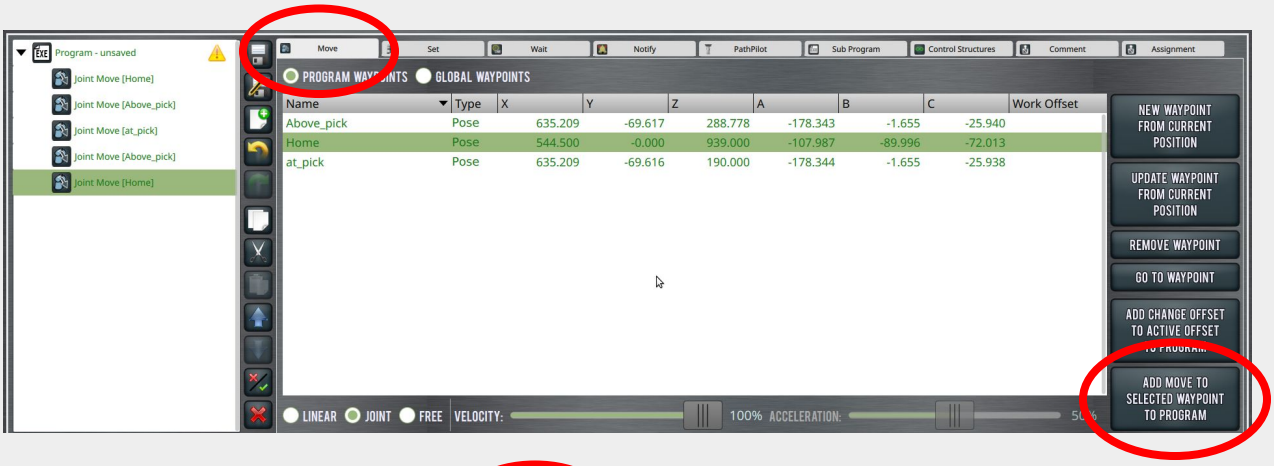
3 Waypoints in Conversational Tab

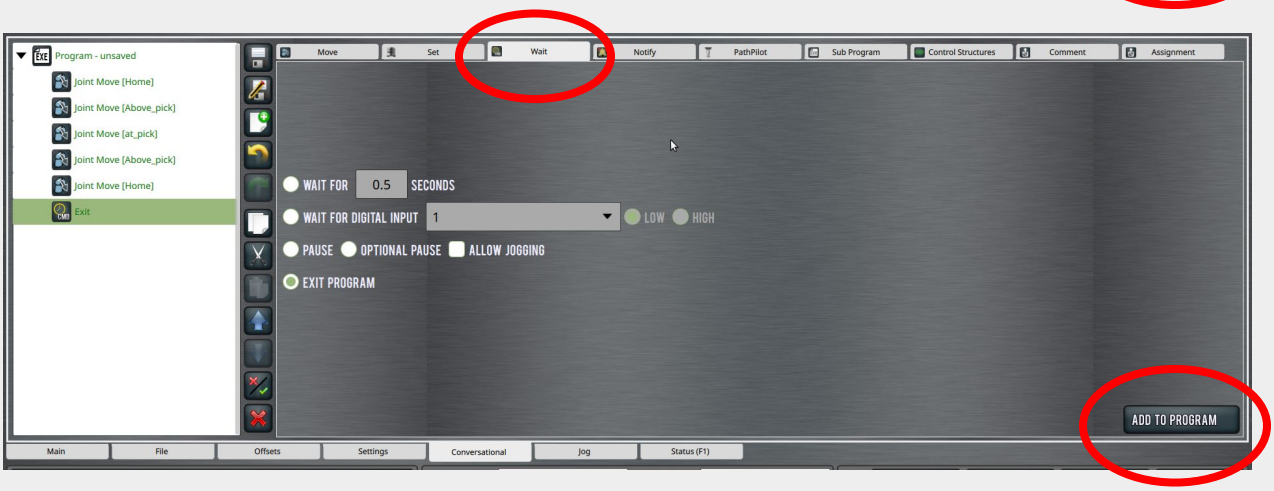


Tormach ZA6 Pick and Place

6. Use the Conversational tab in Path Pilot to record all the positions necessary in **move** waypoints to do a pick and place operation.

- Home (or safe location of your choosing)
- Above Pick
- At Pick
- Above Pick
- Home
- End Program

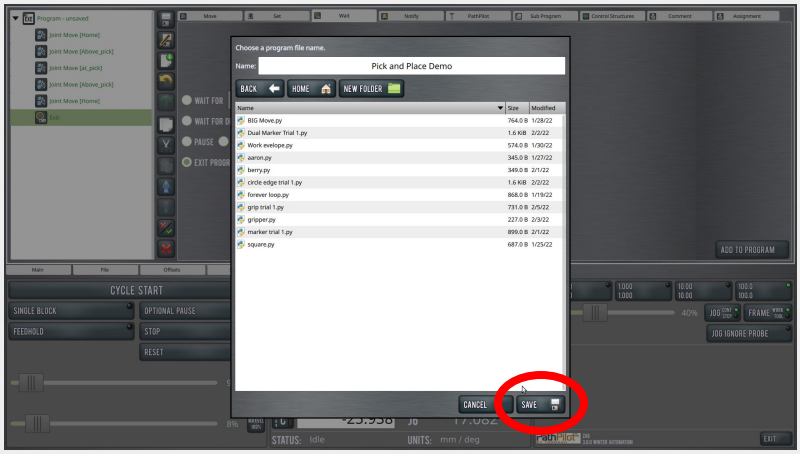


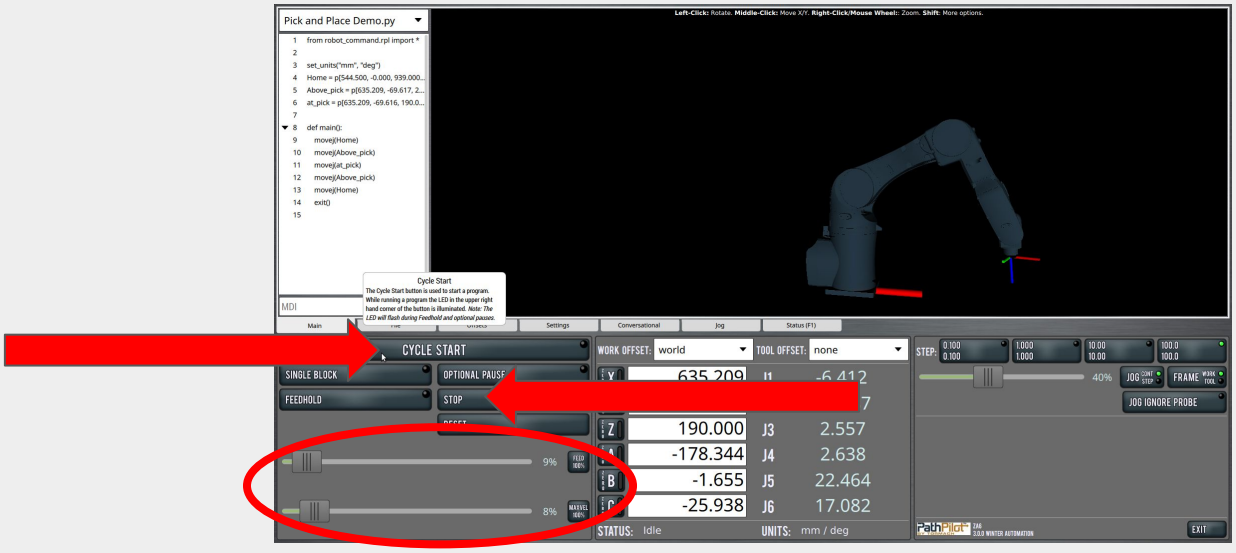


Tormach ZA6 Pick and Place

7. Check to see if your robot moves to the correct locations.

- Save your conversational program as **PICK_AND_PLACE_YOURNAME**.
- Go to the **FILE** tab and load your program
- Mark where your object should be placed
- Remove all obstacles from the work envelope INCLUDING people
- **Slide your FEED and MAXVEL to no more than 10% speed.**
- Press **CYCLE START** and be prepared to click **STOP** or the emergency stop button if you run into an error.





Tormach ZA6 Pick and Place

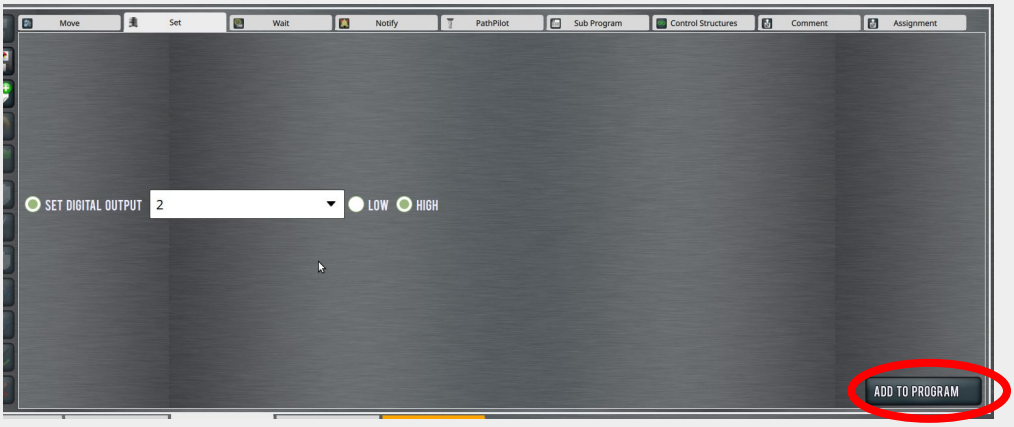
Did it work the first time? If not, what did you have to change to make it work?

8. Record below when the pneumatic gripper should be open or closed (circle your selection of Open/Closed below).

- Home (or safe location of your choosing)
- Open / Closed
- Above Pick
- Open / Closed
- At Pick
- Open / Closed
- Above Pick
- Open / Closed
- Home
- Open / Closed

9. Use the Conversational tab in Path Pilot to record all the positions necessary in **set** waypoints to do a pick and place operation.

You can click, hold, and drag the operation to the correct spot in your sequence

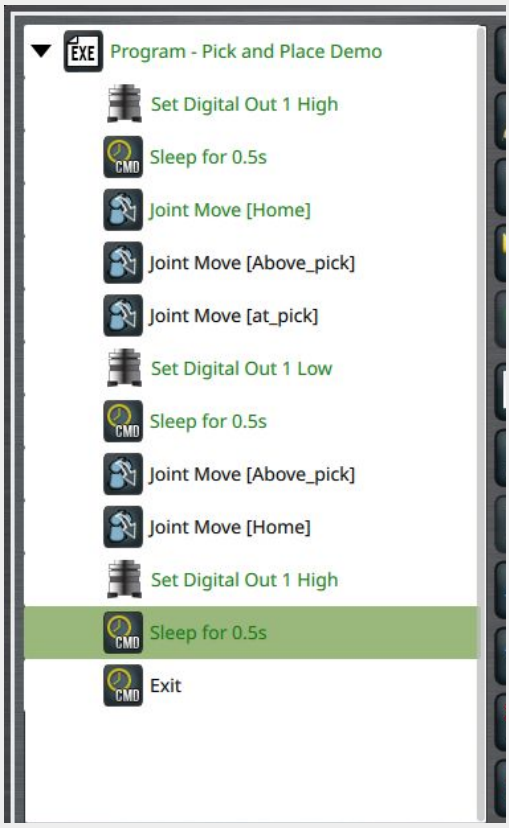


Tormach ZA6 Pick and Place

10. Add in a delay to the gripper to perform the operation.

You can click, hold, and drag the operation to the correct spot in your sequence

Below is an example of what your program should look like. *The I/O on your sequence might be opposite of this example depending on how your airlines are attached to the gripper*



Tormach ZA6 Pick and Place

11. Test your file!

- Save your conversational program as PICK_AND_PLACE_YOURNAME.
- Go to the FILE tab and load your program
- Mark where your object should be placed
- Remove all obstacles from the work envelope INCLUDING people
- Slide your FEED and MAXVEL to no more than 10% speed.
- Press CYCLE START and be prepared to click STOP or the emergency stop button if you run into an error.

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

Place your ¾" cylinder into your work envelope on your previously marked location and run your file.

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

Tormach ZA6 Pick and Place

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.

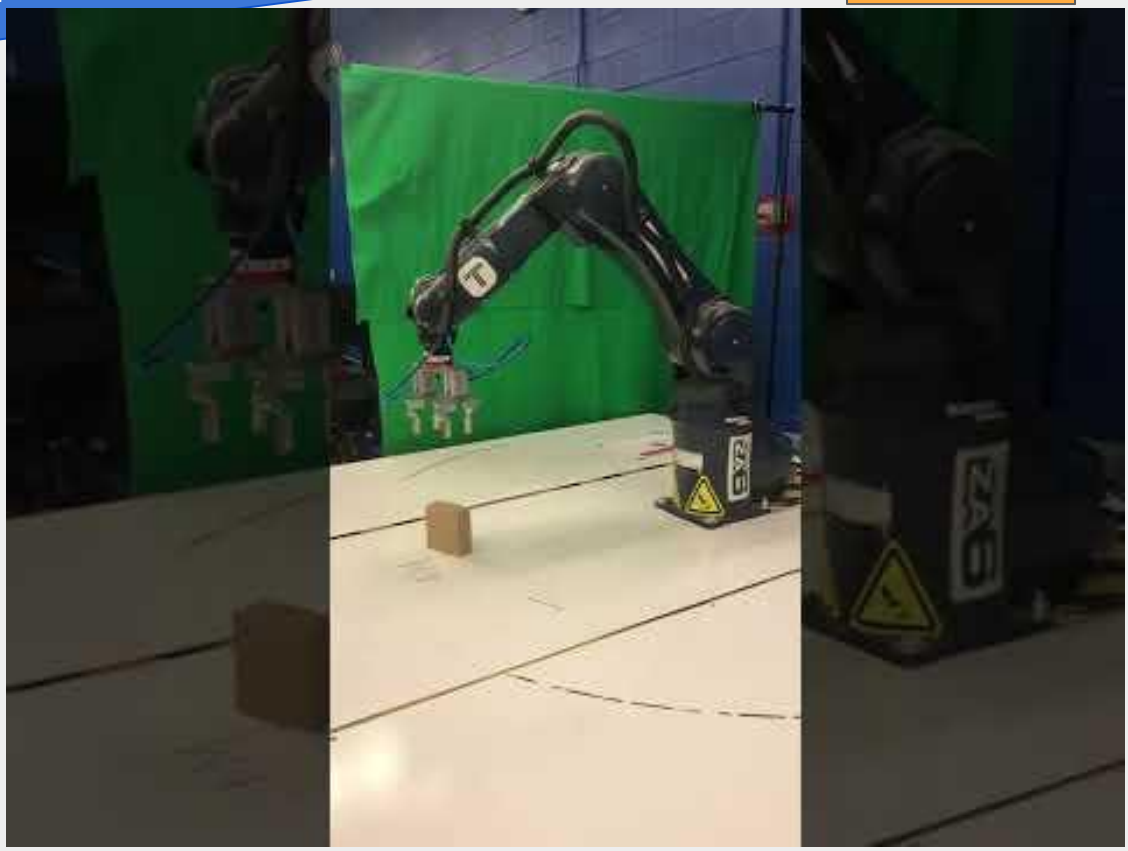
_____ 1. Have the robot reverse the process and put the cube back in its original place.

_____ 2. Make the process happen multiple times.

_____ 3. Adjust the speeds (DO NOT GO ABOVE 30%) of each position to increase efficiency but not lose accuracy.

Tormach ZA6
Pick and Place with Python

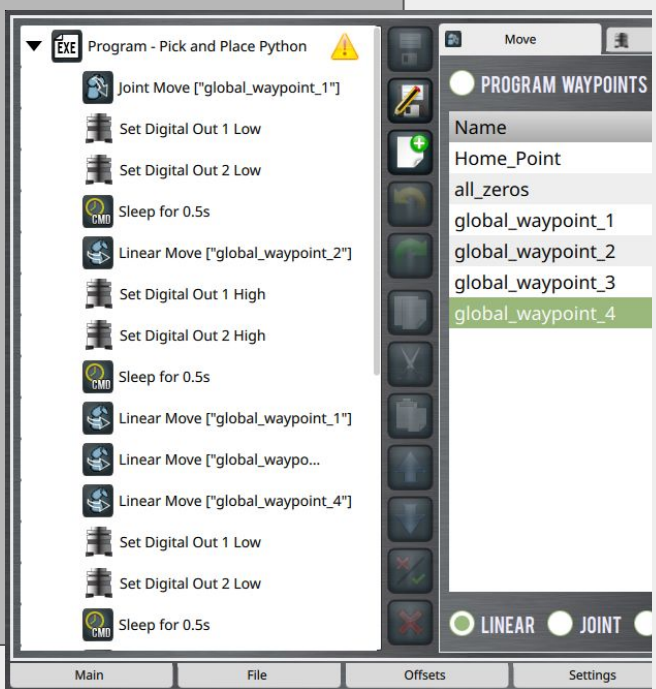
-Video Clip-
Click on Picture



INTRODUCTION

A unique feature to the ZA6 is it can be programed with a computer language called Python. For this skill builder you will combine conversational programming of a Pick and Place motion with a Python code to include a text to talk function as well as notifications and warnings within the sequence.
This will require at least 5 points to start:

- 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



Tormach ZA6
Pick and Place with Python

Writing a code that will run an industrial robot can be dangerous if careless mistakes are made. Be sure to know your emergency stop switches and have an instructor present with you while running for the .

KEY CONCEPTS

- Global and Program waypoints
- Conversational programing vs Python Programming
- Editing Python code
- Notifications and Warnings
- Text to Talk and its applications

-Video Clip-
Click on Picture

KEY VOCABULARY

Global Waypoints
Linear movements
Joint movements
End of Arm Tooling (EoAT)
Syntax

EQUIPMENT & SUPPLIES

ZA6 Robotic Arm
ZA6 White Board Field Diagram
¾ inch cylinders
¾ inch cubes
Pneumatic Gripper
Path Pilot software

Tormach ZA6
Pick and Place with Python

PROCEDURE

Caution: NEVER wire anything to the ZA6 while it has power on. ALWAYS turn it off before making connections or damage to the robot could occur.

1. Refer to the previous tutorial on setup of the ZA6 and its End of Arm Tooling

On the back of the robot controller you should see the solenoid switch light correspond with the light icon in the STATUS tab.

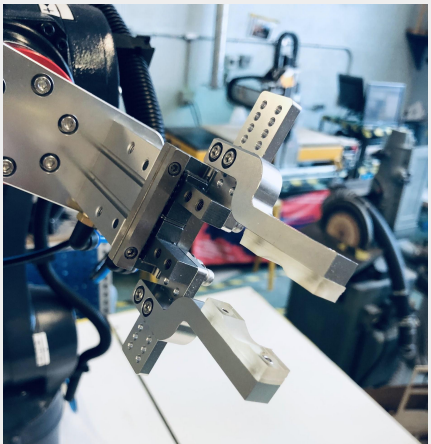
Record below the results from the test (circle your answer):

OUT 1 HIGH (Green light on)

Gripper closed/ Gripper open

OUT 1 LOW (Green light off)

Gripper closed/ Gripper open



OUT 2 HIGH (Green light on)

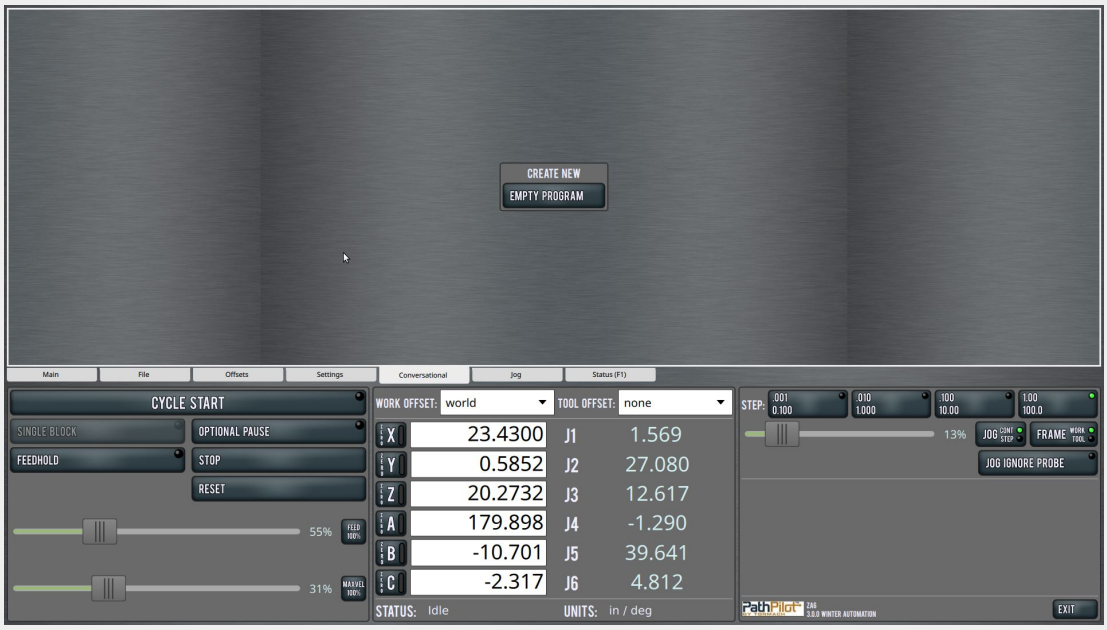
Gripper closed/ Gripper open

OUT 2 LOW (Green light off)

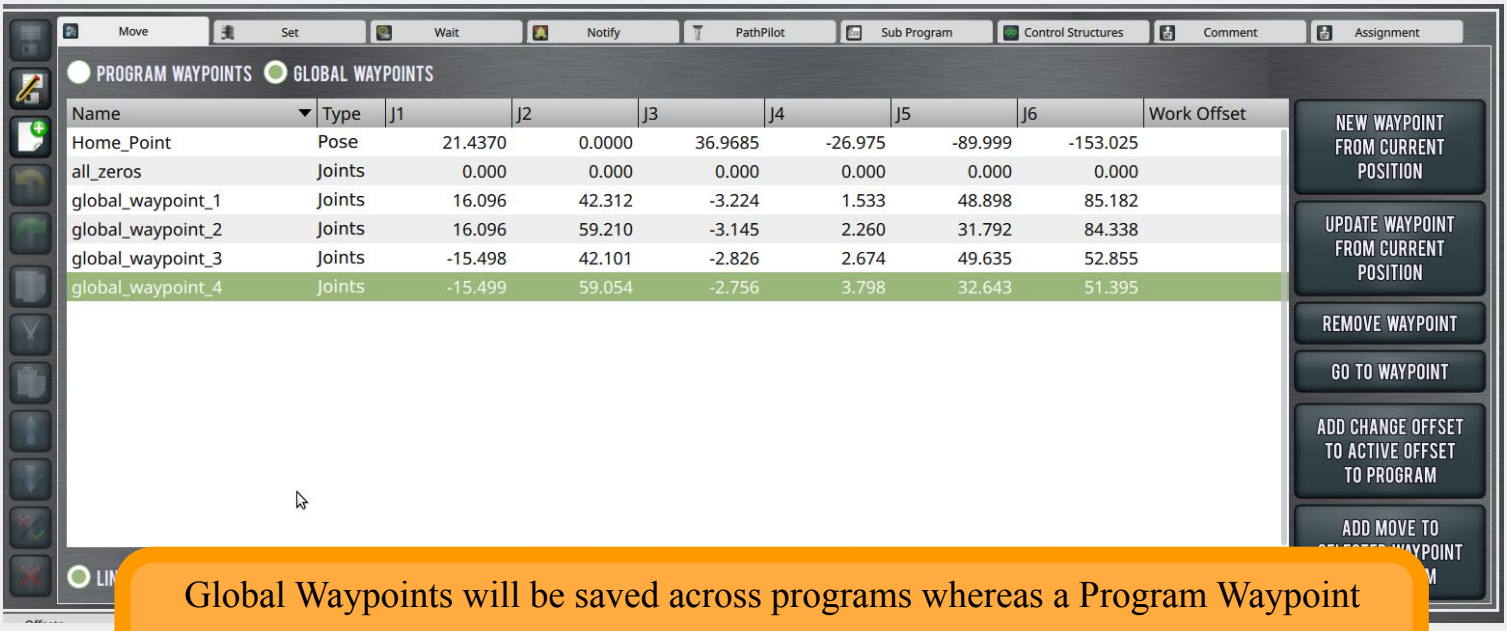
Gripper closed/ Gripper open

Tormach ZA6
Pick and Place with Python

2. Create a new program



3. Using the Tormach ZA6 Tutorial as a reference, create a Pick and Place routine using conversational programming. However, when saving waypoints, save a a GLOBAL waypoint instead of a Program waypoint



Global Waypoints will be saved across programs whereas a Program Waypoint will only be saved within a program. You will use this feature when the robot program is updated in Python.

Tormach ZA6
Pick and Place with Python

4. Test your file!

- Save your conversational program as PICK_AND_PLACE_YOURNAME.
- Go to the FILE tab and load your program
- Mark where your object should be placed
- Remove all obstacles from the work envelope INCLUDING people
- Slide your FEED and MAXVEL to no more than 10% speed.
- Press CYCLE START and be prepared to click STOP or the emergency stop button if you run into an error.

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

Tormach ZA6
Pick and Place with Python

You don't have to know everything there is to know about technology in order to use it- you just have to know enough to NOT hurt yourself, others, or the equipment- Let's learn how to edit a PYTHON code as we go

5. Open the Python Working file

- Access the file here: LINK
- Editing a Python file can be done within the ZA6 software or a text editor such as notepad.
- Change the units in the code to "in" instead of "mm"

```
1   from robot_command.rpl import *
2
3   set_units("mm", "deg")
4
5   import sh
6   import os
7
8   # import MP3 player
9   try:
10      sh.dpkg_query("-W", "mpg321")
11  except:
12      notify("The first time this program is run it must import two packages (MP3 player, Google's text-
13      "This may take a minute or two depending on your internet connection.  Subsequent program runs wil
14      with sh.contrib.sudo:
15          sh.apt_get("install", "-y", "mpg321")
16
17  # import Google's text-to-speech package
18  try:
19      from gtts import gTTS
20  except:
21      from sh import pip3
22      with sh.contrib.sudo:
23          pip3.install("gtts")
24      from gtts import gTTS
25
26  def main():
27      # Copy and paste lines of code from above to make the robot carry out a pick and place routine (Ha
28      notify("You are about to conduct a Pick and Place Routine, Have you had your instructor check your
29      speak("Moving the robot to the home position")
30      movej("all_zeros", v=0.3)
31      notify("Is your work envelope clear of obstacles? Is your item to pick in the correct location?")
32      speak("Lets start a pick and place routine")
33      speak("Moving Robot to Above pick location")
```

- Examples of the code are being edited in a program called visual studio code which allows formatting of Python to be easier to read

Tormach ZA6
Pick and Place with Python

Always have your instructor check your work prior to running your code.

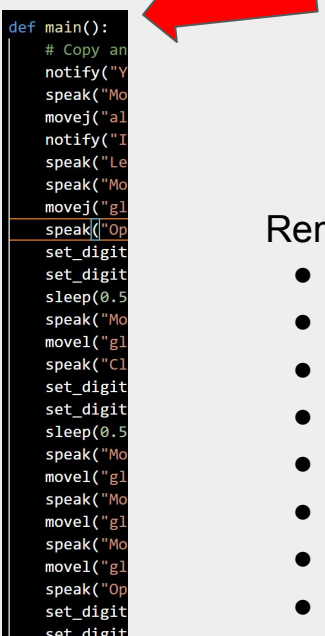
6. Write your Python Code

- Navigate to the def main section
- Copy and paste movej, movel, speak, and set_digital_out to create your pick and place order
- Update the speak lines stating where the robot should be prior to each step
- Update the waypoint names to correspond with the position it should move to
- Update the set_digital_out to the output number and false or true for when the EoAT is open or closed

```
def main():
    # Copy and paste lines of code from above to make the robot carry out a pick and place routine (Have your instructor c
    notify("You are about to conduct a Pick and Place Routine, Have you had your instructor check your code?")
    speak("Moving the robot to the home position")
    movej("all_zeros", v=0.3)
    notify("Is your work envelope clear of obstacles? Is your item to pick in the correct location?")
    speak("Lets start a pick and place routine")
    speak("Moving Robot to Above pick location")
    speak("Opening the Gripper")
    set_digital_out(1, False)
```

Example code snippets:

movej (“global_waypoint_1”)
speak (“insert text here”)
set_digital_out (1, True)
sleep(2)
notify (“insert text here”)



A finished robot program will contain many lines of code that are similar except for minor edits to the speak, move location, and EoAT actuation.

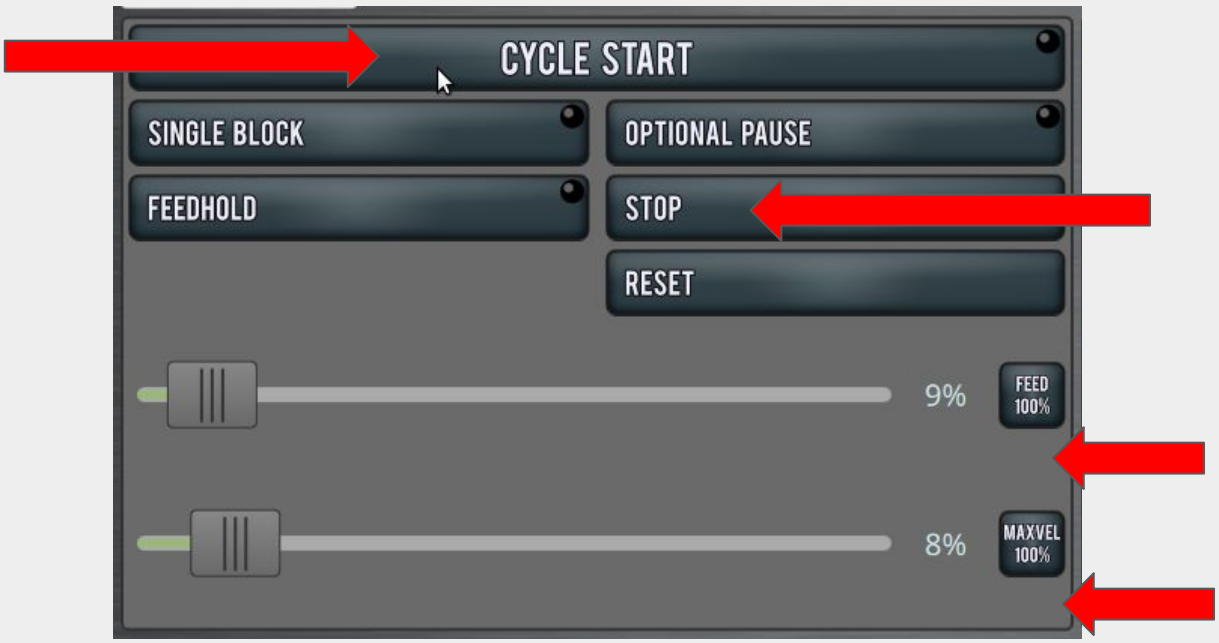
Remember the process!

- 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

Tormach ZA6
Pick and Place with Python

7. Run your Python Robot Program in the simulator

- Save your Python robot program
- Drag the .py file into the robot programs folder
- Open Pathpilot, BUT run it in simulation mode
- Open your file
- Click Cycle Start
- Watch the robot simulation



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

Tormach ZA6
Pick and Place with Python

8. Edit your notification pop-ups

- Watch the below Quick Tips video on creating notifications

-Video Clip-
Click on Picture

The Basic notification will display during a program but it will NOT do what?

How is the Warning notification different from the normal notification ?

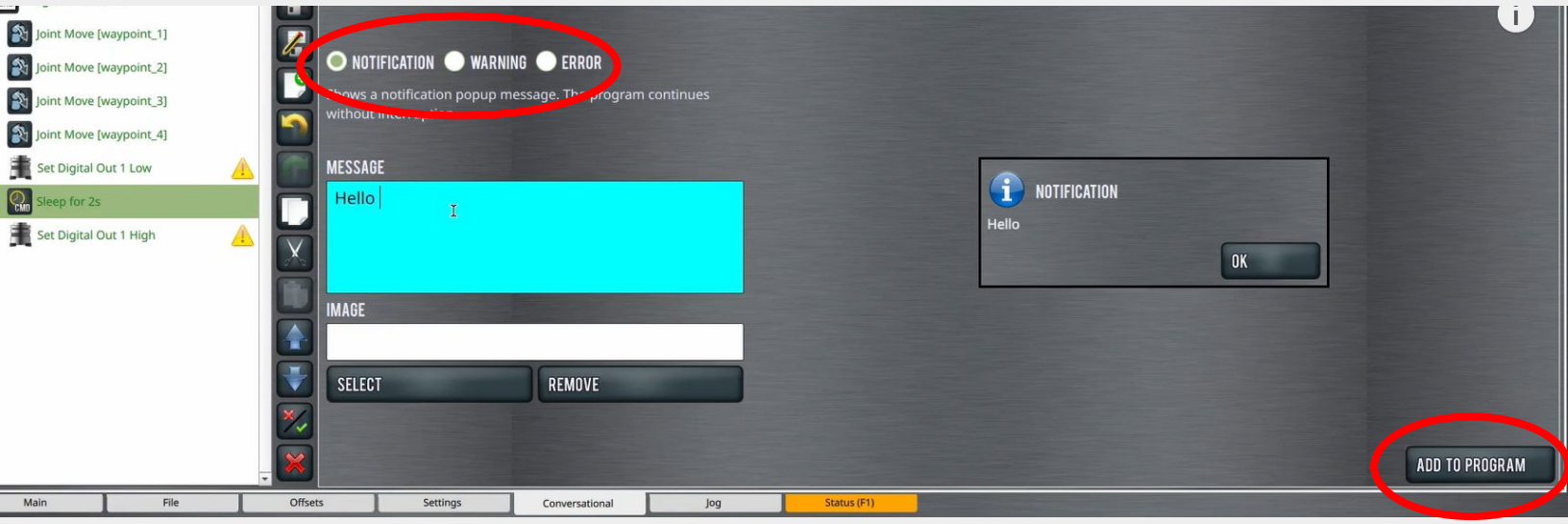
If an error message is used, it will allow the user running the program to only do what?

Why might an image be used with a notification?

Tormach ZA6
Pick and Place with Python

9. Using conversational programming edit your notifications

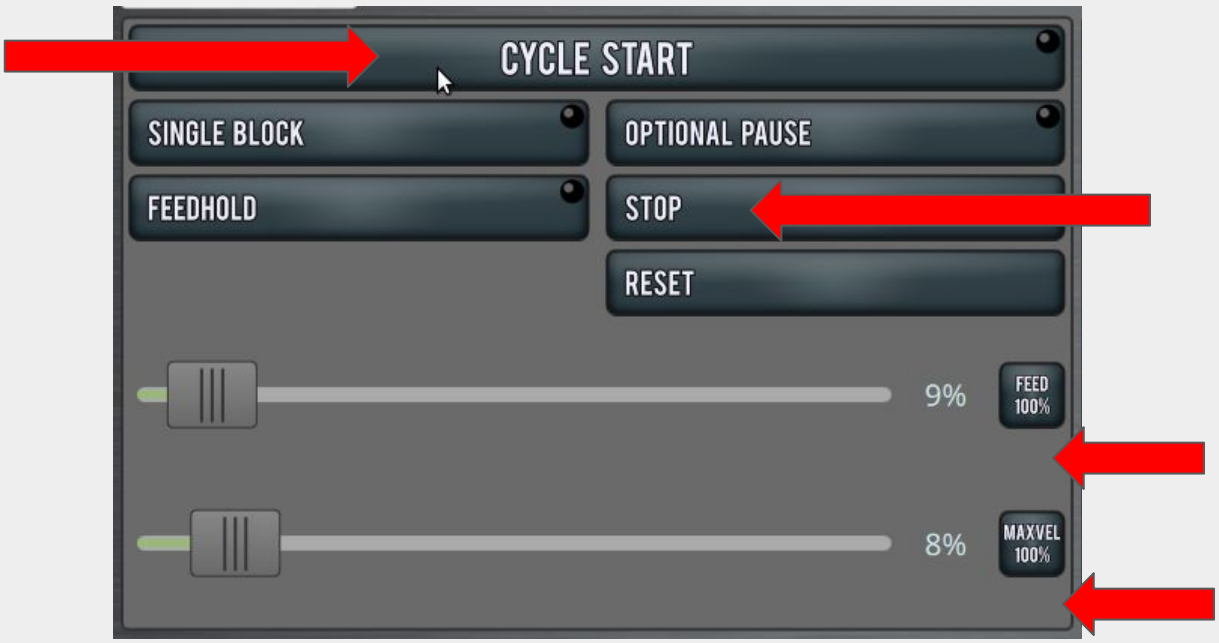
- Change/ add notify commands in the conversational tab to have the program pause and wait for user input to continue the program.
  (Don't know what notify command to use? Rewatch the previous video clip)



Tormach ZA6
Pick and Place with Python

10. Run your Python Robot Program on the Robot

- Save your Python robot program
- Have your instructor check your code & assist you in running the machine
- Turn the Feed and Max Vel down to 10% or less
- Be adjacent to the emergency stop buttons while machine is running



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

Tormach ZA6 Pick and Place

CONCLUSION

1. Why would adding a speak function be useful when writing a robot program? Include a specific example.

2. Why would adding a notification to a robot program help a technician running the machine?

GOING BEYOND

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

_____ 1. Have a notification include an image along with the message

_____ 2. Add additional text of your choosing

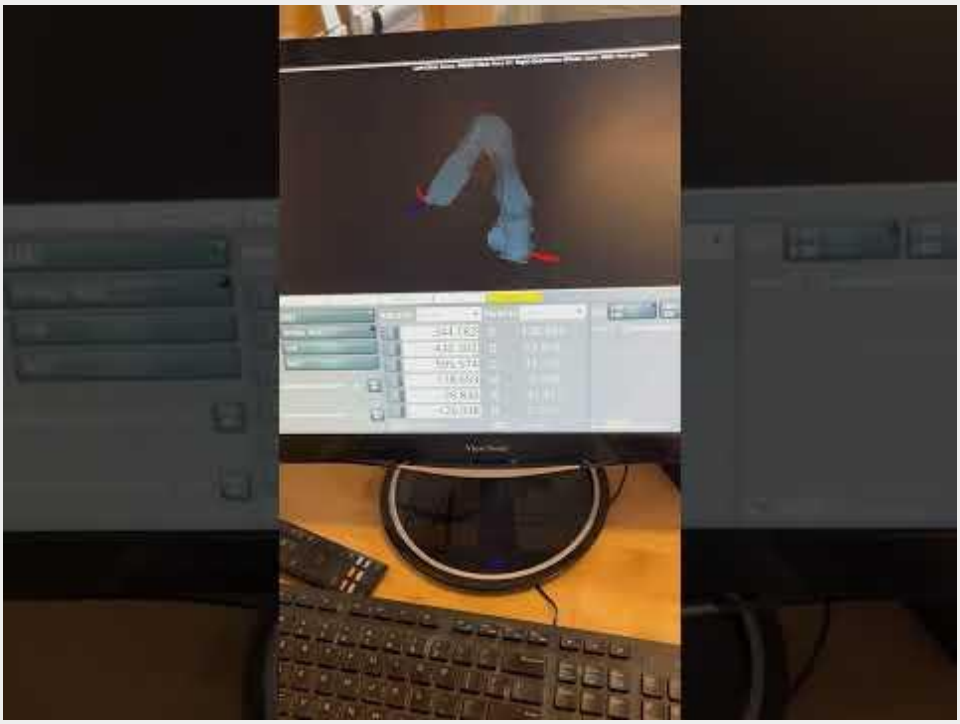
_____ 3. Adjust the speeds (DO NOT GO ABOVE 30%) of each position to increase efficiency but not lose accuracy.

Tormach ZA6 Photo Booth

INTRODUCTION

One of the unique aspects of the ZA6 Robotic Arm is its ability to use Python inside robot programs. There are a number of possible uses for having the robot take photos and store them on the file system. In this example you will be creating a Photo Booth as a jumping off point to explore more possibilities in the future.

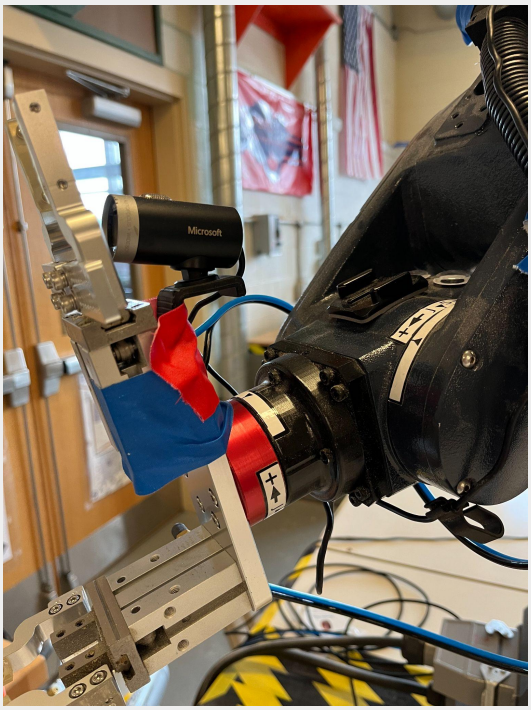
Video Clip
Click on Picture

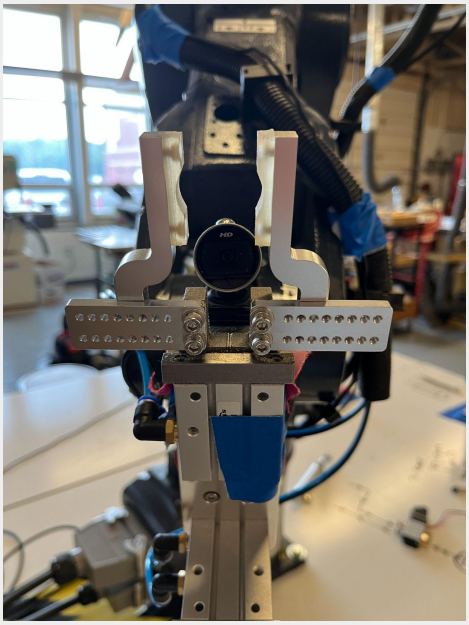


Tormach ZA6
Photo Booth setup

1. Attach a webcam to the ZA6 robotic arm. This example is using a Lifecam from Microsoft. A usb extender will most likely be necessary to make the connection. Be sure to secure the cable to the robot so it will not get tangled in the machine but has enough slack to allow the robot joint to move.

The camera must be plugged in prior to starting the machine for it to be detected.





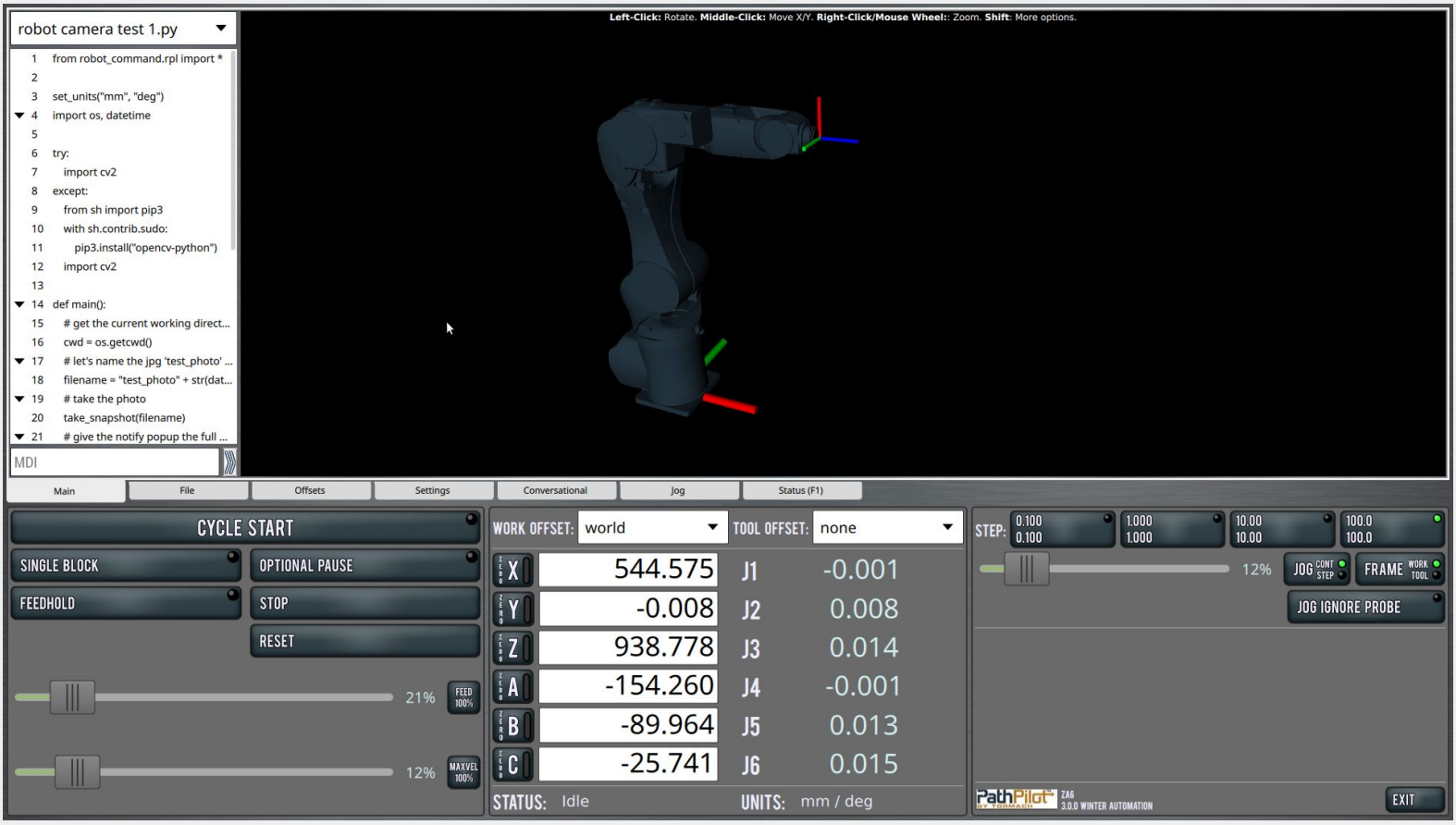
Tormach ZA6
Photo Booth sample code

2. Load the sample Python code from the below link. The file should be placed in the robot programs folder so the ZA6 can locate it.

[LINK]

TORMACH® FORUMS

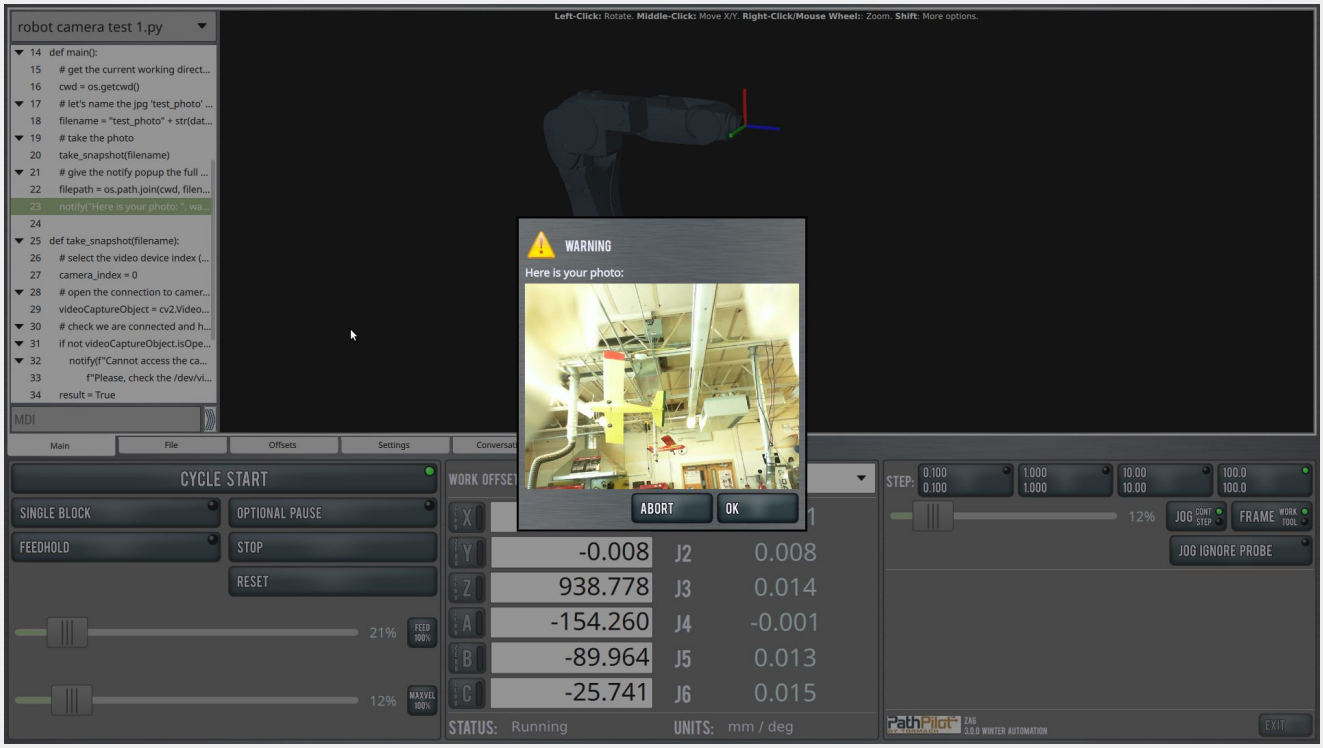
3. In this start file the Python code will not move the robot but test the camera connection. The program will bring up a pop-up warning notification displaying the photo. Scroll through the program, you will notice a subprogram that will direct where the picture will be saved. Subprograms will be covered in future tutorials



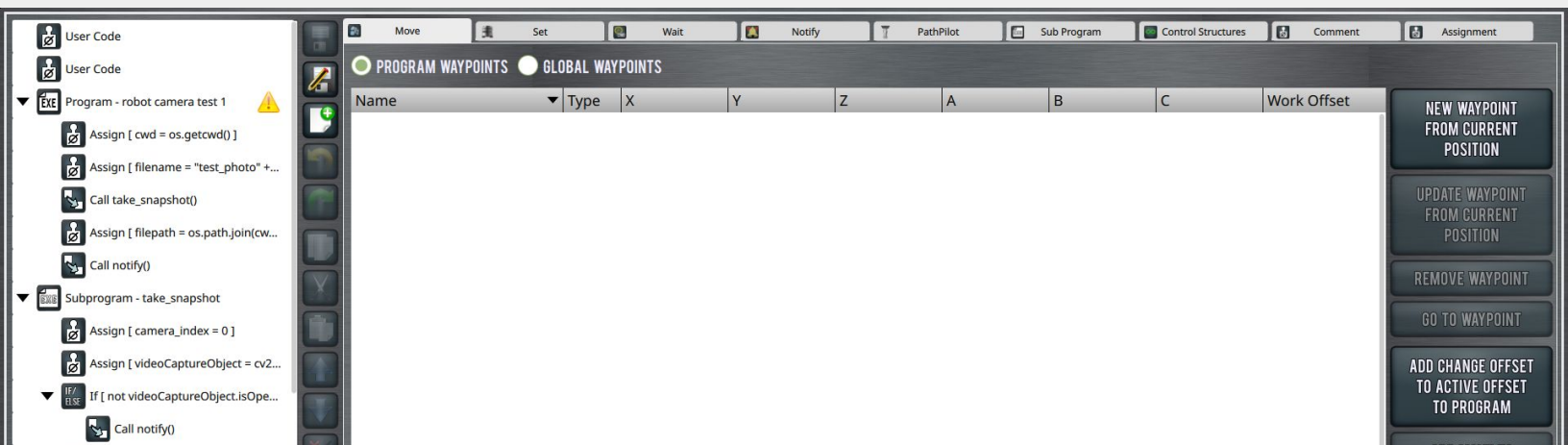
Tormach ZA6
Photo Booth sample code test

4. Run the robot program to test camera connection. If the machine cannot find the camera an error message will be displayed. Often times, when a camera is not detected it is because the accessory was not plugged in prior to starting the machine.

The program will loop until you click abort.

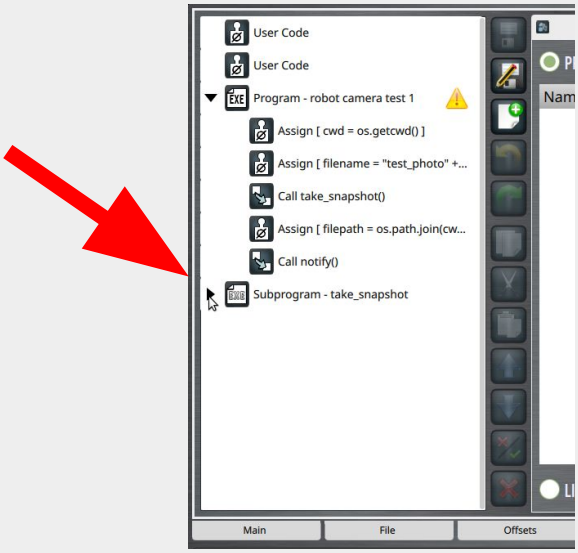


5. Navigate to the **conversational** tab to view the sample robot program. We will add to the sample program through conversational programming because of ease of use.

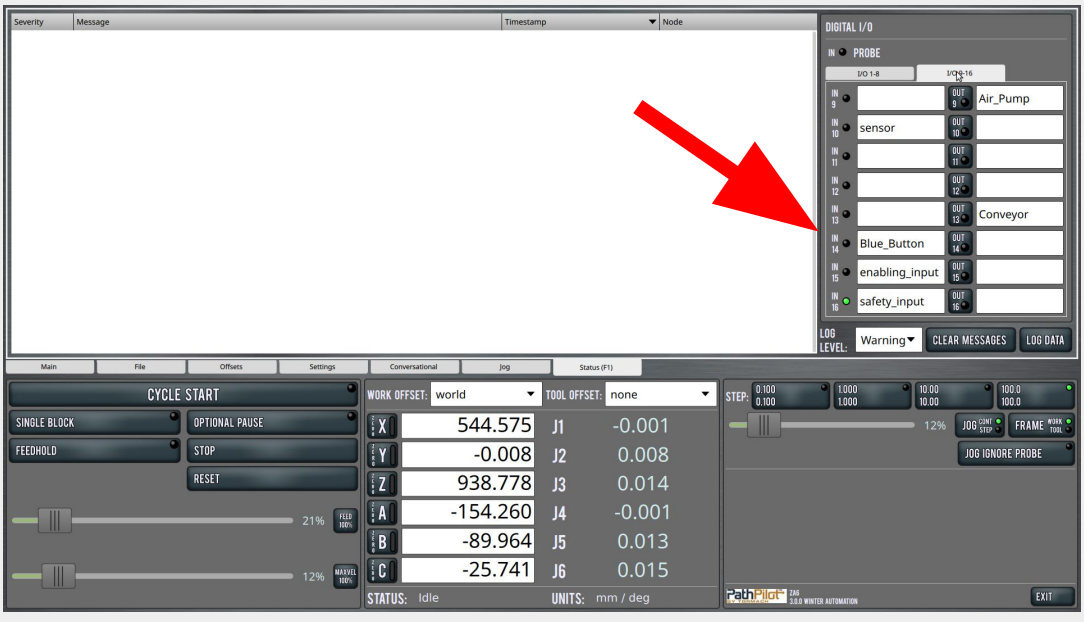


Tormach ZA6
Photo Booth Button

6. Minimize the subprogram for added clarity when editing your code.

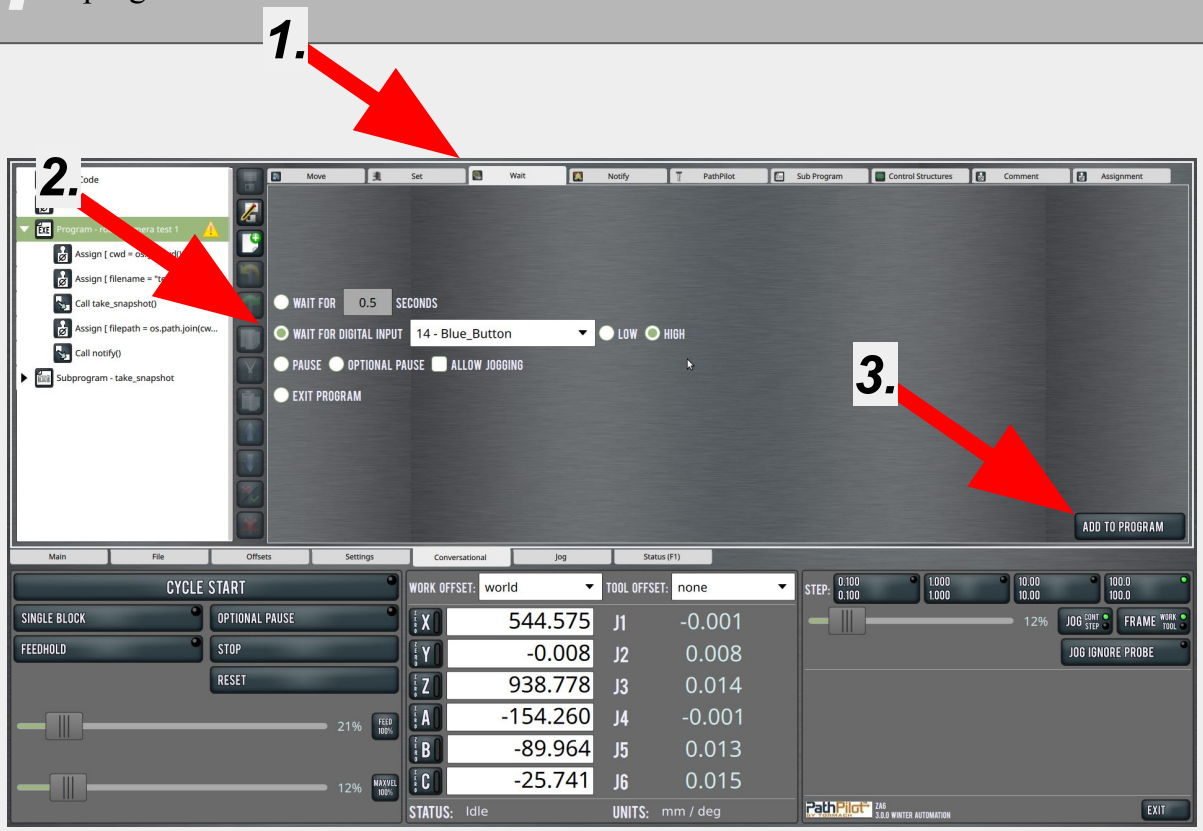


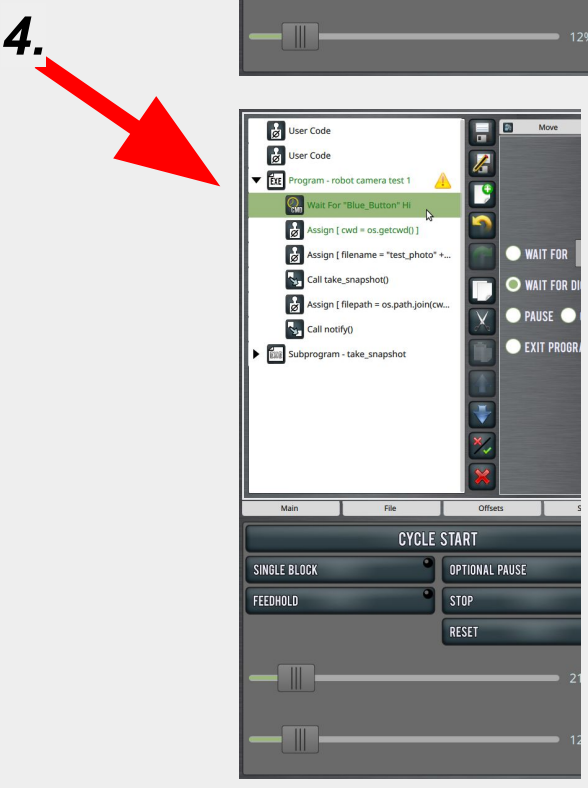
7. An arcade style button works well as an input device (however other input devices can work just as well). Check the connection of your button in the STATUS tab

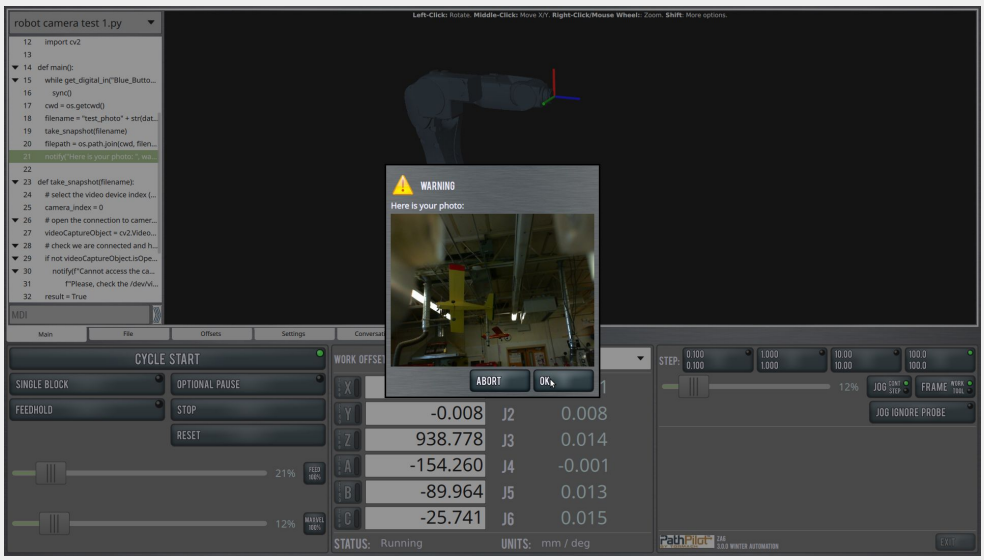


Tormach ZA6
Photo Booth Button test

8. In the **conversational** tab, add a wait command using the button. Save your program and test.

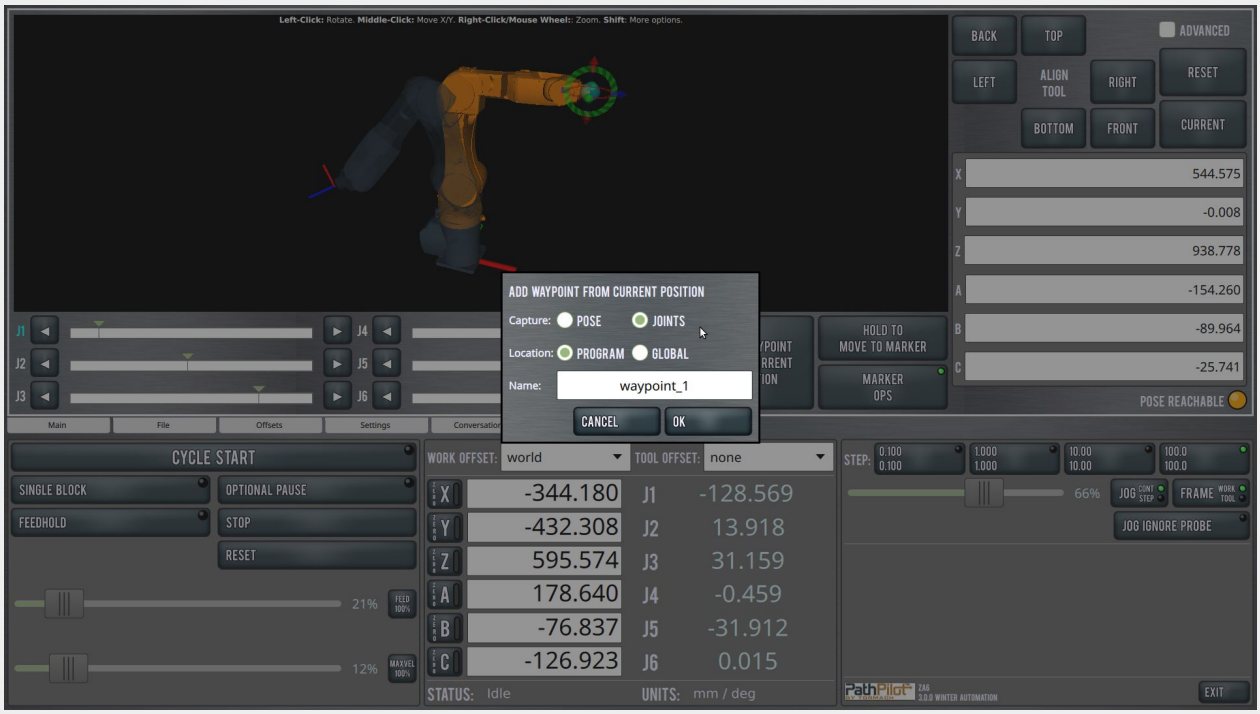




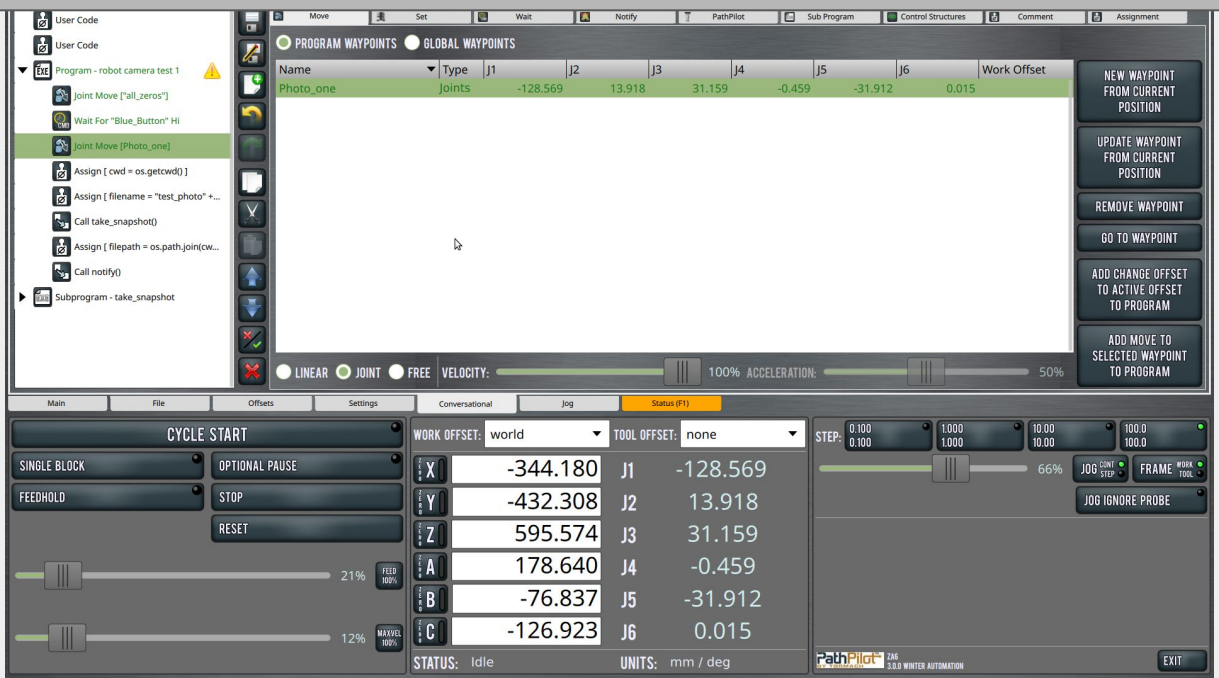


Tormach ZA6
Photo Booth Button with movement

9. In the **Jog** tab, move the robot to a desired photo location. Record the waypoint as a joint type position.

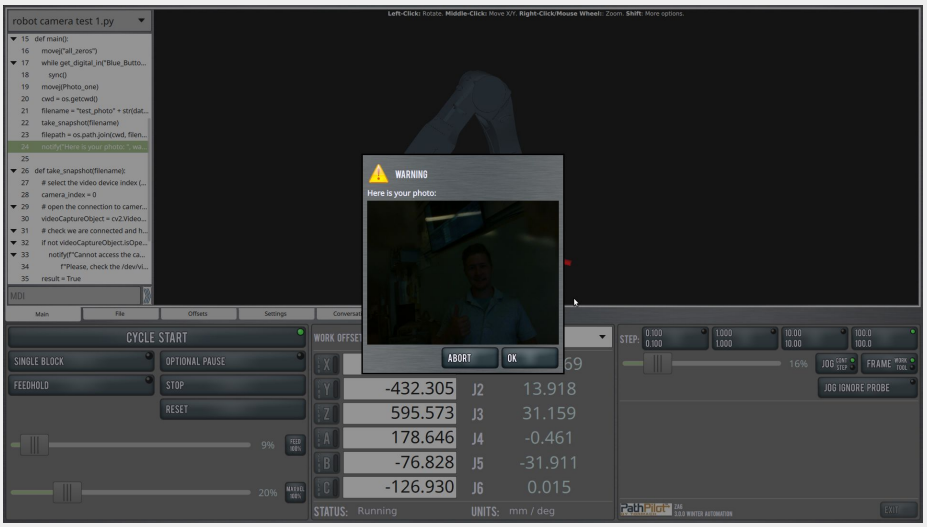


10. In the **conversational** tab, add a move “joints all zeros” from you global waypoints before the button command then add your program waypoint after the button command



Tormach ZA6
Photo Booth Button with movement

11. Have your instructor look at your work (the robot will move this time). Test your robot program.



CONCLUSION

1.Did your robot program work the first time? If no, what steps did you take to troubleshoot the problem?

2. What is the added value of building on a python code in your robot program?

3. What were the sequential steps we took to get to the finish project?

4. Close pathpilot and browse the file folders on your computer. Where are all the .jpg files the robot took being stored? How are they labeled?

Tormach ZA6
Photo Booth going beyond

GOING BEYOND

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

_____ 1. Expand your photo booth to add additional buttons that control more poses for different picture angles.

_____2. Replace the button with a different proximity sensor to convert your photo booth into a security camera

_____3. Have your picture file sent to another location! Navigate to the tormach forums website (link below) to have your picture be saved to the cloud, text message or even sent as a tweet on Twitter

LINK

TORMACH® FORUMS

Video Clip
Click on Picture