Introduction

Vocabulary

Pitch- a movement that moves the end tool around the Y-axis.

Yaw- a movement that moves the end tool around the Z-axis.

Roll- a movement that moves the end tool around the X-axis.

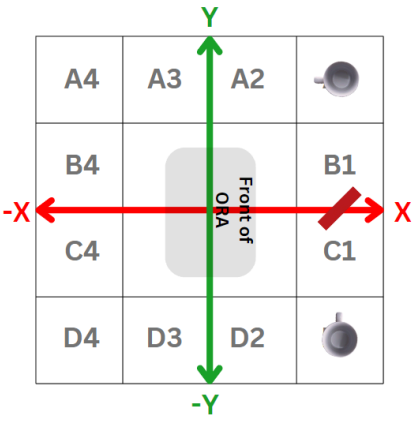
Singularity - a particular point in a robot's workspace that causes the robot to lose one or more degrees of freedom

Engage: Same finger gripper, new tricks!

As students enter the room, have the **EngageL8Code** (Share Code: zoneksr) running on the ORA. Direct students to the Engage section of the Student Activity Sheet and have them describe the motion of the ORA using what they already know (such as X, Y, Z motion, etc). After students have described the motion, show the code on the connected display. Show that the ORA is moving using the Pitch, Yaw, and Roll.

Next, show the Lesson 8 video.

Explore Yaw, Pitch, and Roll in particular use case.



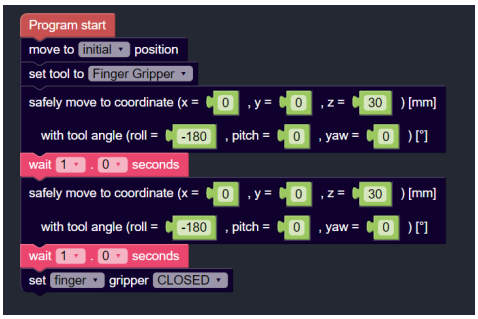
Place two coffee cups and a wooden cylinder on the Quadrant Map as shown in the diagram. The handle of the cup in A1 should be facing in the -X direction, and the handle of the second cup should be in the +Y direction. A red, wooden cylinder should be placed in the middle of the boundary between B1 and C1 canted at a 45-degree angle.

Direct the students to the Explore section of the Student Activity Sheet and have students use their understanding of Pitch, Yaw, and Roll to describe which arm motion would be necessary to pick up the object. Tell students that the coffee cup can only be picked up by the handle perpendicular to the side of the cup (see image), not from the top.

On the student activity sheet, students will also describe the Yaw, Pitch, or Roll motion in terms of angle (how many degrees) and direction (+/- X/Y/Z).

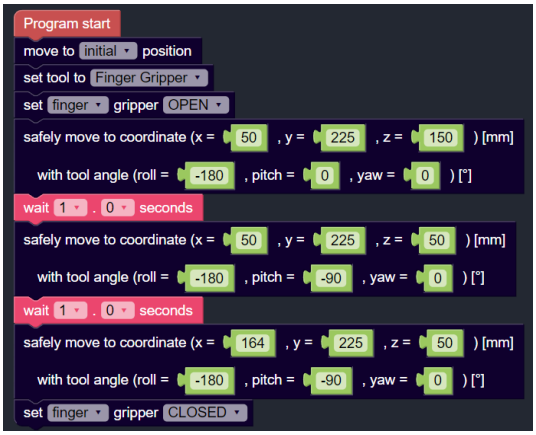
Explain using Yaw, Pitch, and Roll in the ORA Editor.

Open up the ORA Editor and open the **ExplainL8Code** (Share Code: q2tqrxa). It will look like the image to the right.

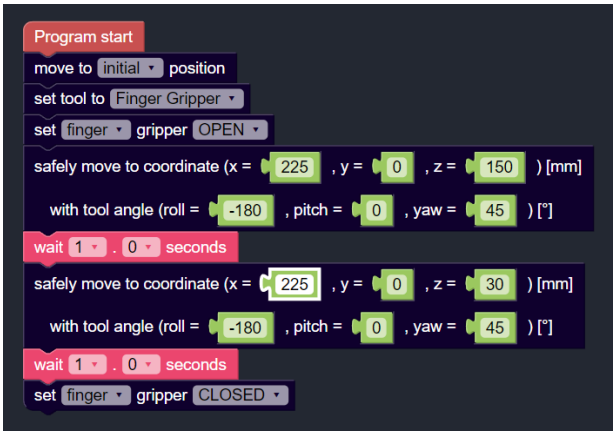


Explain to students that, like some of the other object interactions in previous lessons, we need two **Safely Move to Coordinate** blocks. The **Safely Move** block will help ORA avoid singularities. The first block is to get into position near the object, and the second is to move into the object.

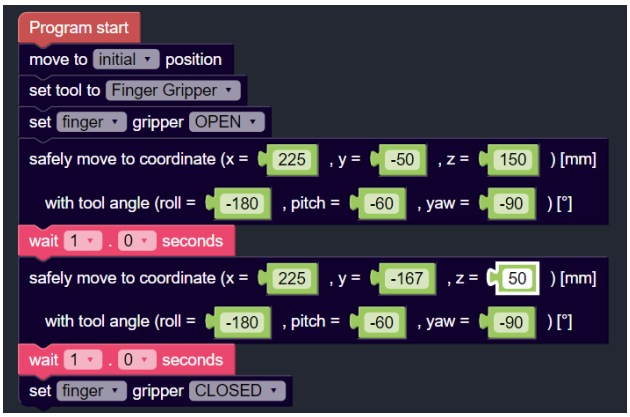
The first coffee cup is located at X=225, Y=225. The diagram has the center of the coffee cup at the center of A1. An example coffee cup handle-gripping location is 80mm from the center. The coordinates would be X=164, Y=225, Z=50. Will vary based on cup choice. The first **Move to Coordinate** block would have X and Y values, no change to Y/P/R and a high Z value well above the height of the cup. Then, the second movement block would move into position using a **-90-degree pitch** movement. You can figure this part out beforehand or work with students to figure it out together.



The coordinates to pick up the wooden cylinder are X=225, Y=0, and Z=20. In this step, only the yaw movement is needed. If the cylinder is oriented like the diagram, a **45-degree yaw** will orient the jaws to pick up the cylinder.

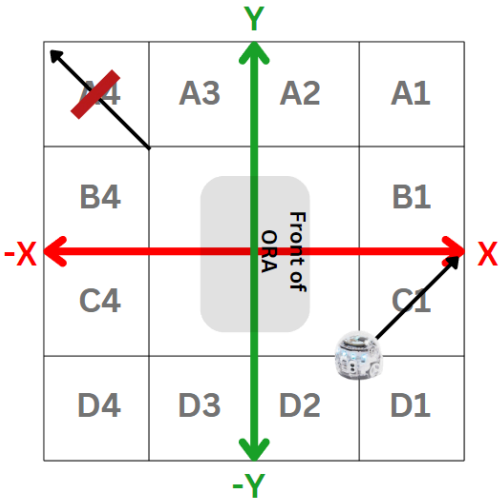


The second coffee cup will be a similar challenge to the first cup with a literal twist! The coordinates for pickup are X=225, Y=-167, Z=50. But if you use **-90-degree roll**, the jaws of the finger gripper will not be oriented so the handle can be picked up by the finger gripper. You must also include a **positive or negative 90-degree yaw** to orient the finger gripper to pick up the cup. Again, tailor these numbers to your coffee cup!



Elaborate: ORA-Evo Concurrency Revisited

In this challenge, students will use ORA to assist Evo in patrolling a specific path around the quadrant map.



Setup: Place two Evo Line cutouts diagonally in C1 and A4 (see diagram, left). Place a wooden cylinder on its side across the Evo Line in A4. Evo will start in the corner of C1/D1/D2 pointed along the Evo Line in C1.

Task Requirements:

1. ORA must start in the Initial Position.
2. ORA must move concurrently with Evo to remove the obstruction before Evo reaches the corner where B1/C1 meet.
3. ORA must pick up the obstructing wooden block and place it, on end, in the middle of A1.
4. After the obstruction is cleared, ORA will pick up Evo and place it at the corner of A3/A4/B4 turned so that it will follow the line.
5. ORA and Evo will again run concurrently as Evo finishes the patrol and ORA returns to the initial position.
6. Evo will light up to signal the completion of the patrol at the outside corner of A4.

Direct students to plan this code in the Elaborate section of their Student Activity Sheet. After creating the pseudocode and drawing the code, direct them to create this code on their devices in the ORA Editor (example of code **ElaborateL8Code** Share Code: 9up7zad). Ensure students are connected to your shared workspace.

As students complete their code, they will test their code. Click on a given student's or student group's tab on the ORA Editor. Click "Run" to execute their code. Reset Evo and the cylinder between each code run. Remember to follow the Safety Protocol established in Lesson 1.
If students are waiting for the ORA, they could:

- Answer Questions on the Student Activity Sheets.
- Complete the Evaluate section of the Student Activity Sheets.

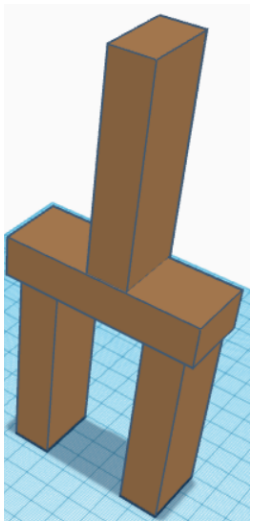
Evaluate: Exit Ticket

Students will fill out and submit the Evaluate section of the Activity Sheets which is the last page of the Student Activity Sheets.

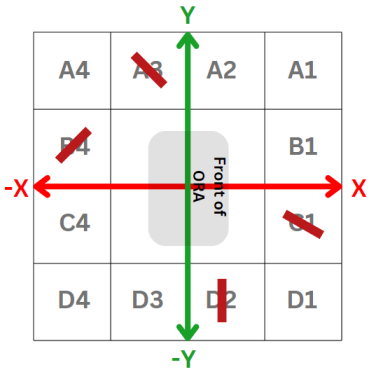
Optional Extension: Precision Homebuilder

In this activity, students will program an Automated Modular House Building Cobot to build a simple structure. Automated housing construction is a way to create inexpensive housing for the world's growing population.

Source: Canva



In this task, students will collect four Jenga blocks from around the quadrant map and create a simple structure (see image, left) with the blocks.



Setup: Place four Jenga blocks around the Quadrant Map in A3, B4, C1, and D2. These will be in different orientations (-45-degrees, +45-degrees, +30-degrees, +/-90 degrees, respectively)

Task Requirements:

1. ORA must start in the Initial Position.
2. ORA must use precise X, Y, Z, and yaw, pitch, and roll motions. To pick up and orient the blocks.
3. The structure must resemble the one pictured above left.
4. The structure must be built in A1.
5. When placing the blocks in the structure, a Yaw, Pitch, and Roll command must be used at least once in the challenge.
6. ORA must return to the Initial Position when the structure is complete.