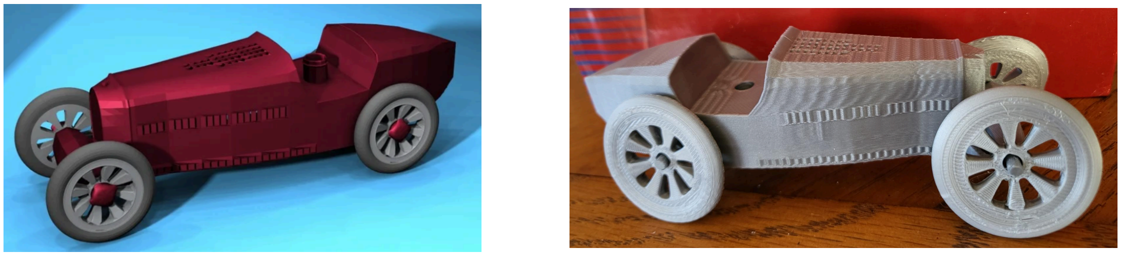
Robot Arm, Assemble!



Balloon Bugatti Type 35 by Sisyphus

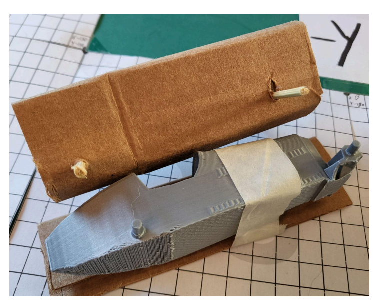
If you do not have access to a 3D printer, you can substitute the Balloon Bugatti with a few other options:

Option 1: Wooden Car: The [half-size] Bugatti's dimensions are roughly 120mm x 31mm x 30mm. This is approximately 4.75 x 1.2 x 1.2 inches.
Materials:

- 2, 2x2 pieces approximately 4.75 inches in length
- 4, 1/8th inch dowels approximately 1.75 inches in length
- 8 plastic soda bottle caps

Directions

- Drill two 1/8th inch holes all the way through the side of the car. If you want to approximate the holes for the axles of the model car, they are 0.3 inches up from the bottom. The front axle is approximately 0.3 inches from the front of the car, and the rear axle is approximately 1.25 inches from the rear of the car.
- Insert the dowels until they stick out from each side of the car equally. Glue these axles in place.
- Drill 1/8th inch holes in the center of the 8 soda bottle caps. These will be the wheels.



Option 2: Cardboard Car: This will be similar in size/dimensions and materials to the wooden car. Instead of a 2x2, the body will be constructed out of cardboard. Follow the same steps for including axles and wheels.

Note: Due to size restrictions of the 3D printer used in the testing process and the width of the finger grippers, the model has been scaled approximately 50% smaller than the original model found on Thingiverse.

Direct Instruction

Engage with Assembly Lines!

Start the Engage section by presenting the students with the lesson challenge. Tell students:

"For this challenge, you will assume the role of Automated Manufacturing Technician at ORA Mechatronics. Bugatti International, a regional manufacturer of fancy, French cars, has hired your team to use ORA as an Automotive Assembling Cobot. If you can prove that ORA can successfully be programmed to work alongside humans to assemble automobiles, then your company will be awarded the contract!

Have the students spend a few minutes thinking about assembly lines and answering the questions in the Engage section of the Student Activity Sheet. Then tell the students:

"Before we can solve this challenge, we need to learn more about robotic arms in automotive assembly lines and the careers related to them!"

Next, show the Lesson 8 video.

Explore Automated Manufacturing Technician Career Connections

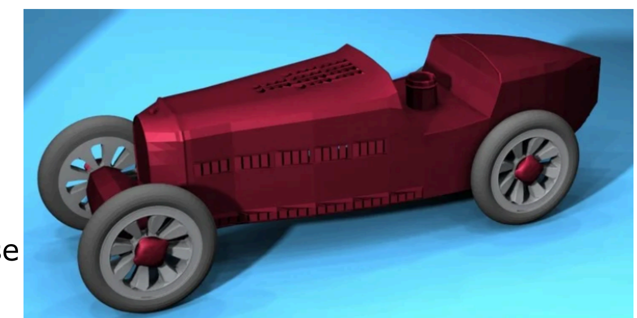
Students will do a brief guided virtual scavenger hunt related to the Automated Manufacturing Technician career connection. Individually or in small groups, have them complete the Explore section on the Student Activity Sheet. If students are struggling with the job outlook section, have them go to the US Department of Labor and Statistics Occupational Outlook Handbook. In this tool, you can find information about thousands of jobs. On the Index page, search for your career (Use Ctrl+F on a Windows machine or Chromebook). When you click on the career of your choice, there is a short video about the career as well as several key pieces of information. Automated Manufacturing Technician is not available on this list, but there is a Team Automobile Assembler, which is a subset of assemblers and fabricators that is applicable.

Explain the uses of robotic arms in the Automotive Industry.

Start the Explain section by asking the students "How are robotic arms used in the automotive industry?" Students should be able to recall from the video different aspects of the automotive manufacturing process using robotic arms such as lifting heavy objects, precisely picking and placing components, and painting parts.

As discussed in the video, robotic arms are used in many ways in the automotive industry, including:

- Welding: Robotic arms perform spot and arc welding, which is essential for ensuring the structural integrity of a car.
- Assembly: Robots can assemble specific parts, like engines, or multiple parts, like wheels and chassis. They can also perform tasks like screw driving and windshield installation.
- Painting: Robots can spray paint parts and vehicles, and also polish them.
- Quality inspection: Robots use advanced vision systems to inspect finished vehicles.
- Material handling: Robots can move heavy parts and vehicles along the assembly line.
- Cutting and milling: Robots can perform cutting and milling operations to create parts of a specific shape and tolerance.
- Machine tending: Robots can load and unload parts from machines like CNC machines and presses.
- Packaging and palletizing: Robots can package completed vehicles and prepare them for shipment.



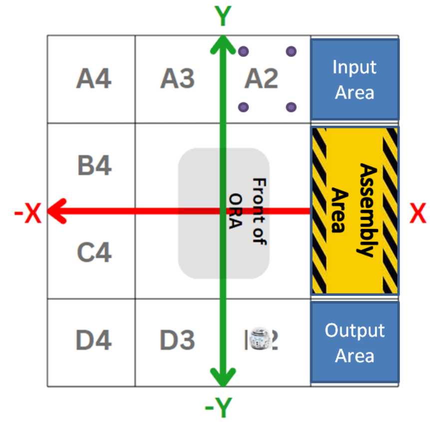
Ask the students, "Of the uses of robotic arms listed, which one(s) will we need to utilize in the lesson challenge?" [Assembly and Material Handling]

Show the students an assembled car. Tell students that they will need to use ORA to move/maneuver/manipulate the chassis to put on the wheels on one side of the car. Show the students the chassis of the incomplete car. Since the axles stick out, the students cannot simply put the car on its side to place the wheels on the axles. The students will need to make a fixture or a tool that holds a part steady in a fixed position, orientation, or location while a task is performed, out of cardboard.

Note: How the car is held in place and/or oriented is entirely up to the students.

Elaborate: Cobot-Human Assembly Team!

In this challenge, students will build a fixture to hold a model car in place while ORA puts on the wheels. ORA will return to the initial position and wait while a human adds the hub caps to the axles. ORA will then move the car over and repeat the process with the second car. Students will also program Evo to concurrently notify the human worker when it is safe to enter the workspace to attach the hubs.



Setup:
Have students place the two car chassis in their fixtures in A1. Place the four wheels in A2, outside face facing up, on wooden cylinders. Tape the wooden cylinders to the mat to keep them in place. Place Evo in D2. The hubs will be out of the ORA mat workspace in the hands of a human assembly line technician.

Task Requirements:
1. ORA must start in the initial position.
2. ORA must use the finger grippers to pick up a car chassis from the Input Area and move it to the Assembly Area.
3. ORA will pick up two wheels from A2 and place them on the top axles of the car.
4. ORA will return to the initial position while the human coworker places the hubs on the axles.
5. After the hubs are installed and the human technician is out of the way, ORA will move the wheeled chassis to the output area.
6. ORA will then move the second chassis into the assembly area and repeat the wheel-adding process.
7. ORA will return to the initial position while the human coworker places the hubs on the axles.
8. ORA must wait at **least 60 seconds** for the technician to add the hubs and move to safety.
9. After the hubs are installed and the human technician is out of the way, ORA will move the wheeled chassis to the output area.
10. Evo must illuminate red when humans must be out of the ORA workspace, green when humans may enter, and audibly notify humans when ORA is ready to commence work again.
11. ORA must finish in the Initial Position.

Direct students to plan this code in the Elaborate section of their Student Activity Sheet. After writing the pseudocode, and drawing the code blocks, direct students to create the code on their devices in the Ozobot Editor. Ensure students are connected to your shared workspace.

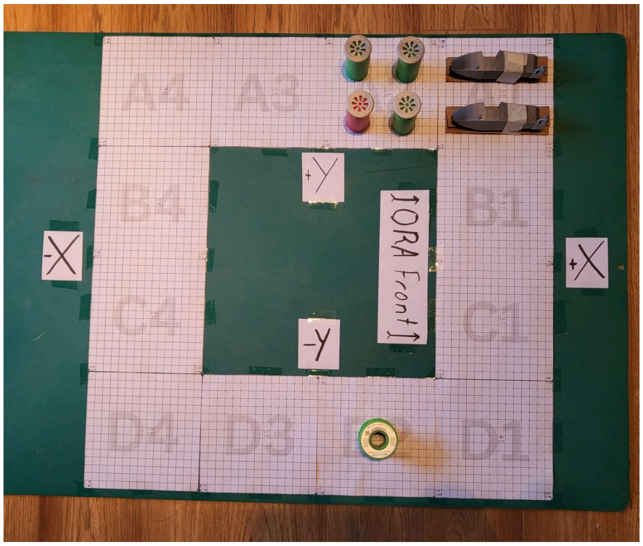
As students complete their code, they will test their code. Click on a given student's or student group's tab on the Ozobot Editor. Click "Run" to execute their code. Reset the materials between each code run. Remember to follow the Safety Protocol established in ORA Essentials. [Example solution code.]

If students are waiting for the ORA, they could:

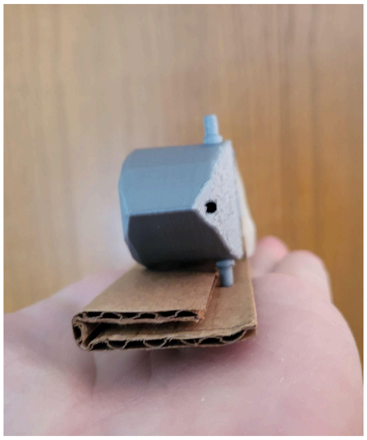
- Complete the Evaluate section of the Activity Sheets as an exit ticket.

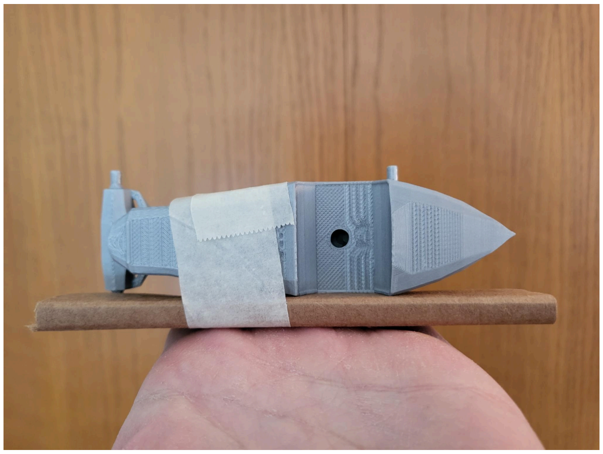
Elaborate: Example solution

1. **Setup**
    a. Right is an image of the setup for the lesson challenge.



2. **Designed Materials**
    a. For this challenge, the students will create a fixture to hold the car on its side with the axles vertical. A quick solution is to create a base from cardboard and tape as shown below.
    b. Alternatively, there is an STL file for a pre-supported chassis if doing a lesson without the fixture.



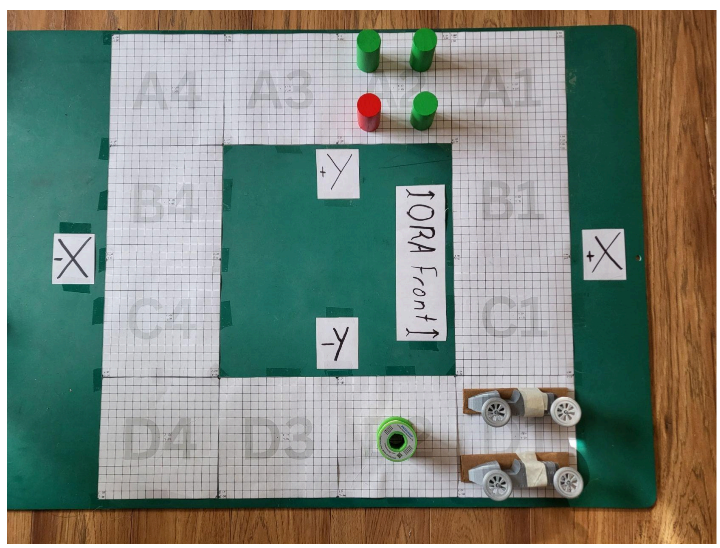


3. **Sample Code**
    a. [Example Solution Code]

4. **Code Description**
    a. The code begins when Evo lights up red and ORA moves to pick up the first chassis from A1. The chassis is rotated and placed at the junction between B1 and C1. Two of the wheels from A2 are picked and placed on the top axles. ORA returns to the Initial Position and waits 60 seconds for the human technician [student] to place the hubs on the axles while the ORA is in the Initial Position, Evo lights up green. When ORA is about to move, Evo will light up red and emit a series of notes. ORA resumes operation by moving the finished chassis to D1 and picking up the second chassis from A1 and places it between B1 and C1. The final two wheels are added to the second car. ORA returns to the Initial Position and waits 60 seconds for the human technician [student] to place the hubs on the axles while the ORA is in the Initial Position and Evo lights up green. When ORA is about to move, Evo will light up red and emit a series of notes. ORA resumes operation by moving the second finished chassis to D1. ORA finishes by moving to the Initial Position and Evo lights up green. Below is an image after the program has been executed.

Evaluate: Exit Ticket

Students will fill out and submit the Evaluate section of the Activity Sheets as an exit ticket.



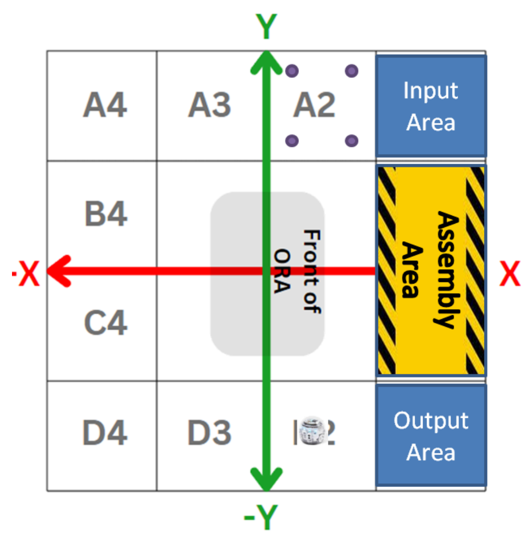
Optional Extension: Assembly Optimization

In this activity, students will work on optimizing the program in the Elaborate section to increase efficiency and output!

Rather than just cranking up ORA's movement speed, students will focus on the time it takes the human coworker to add hubs to the axles after ORA places the wheels on them and returns to the initial position

Source: Canva

Setup: Use the same setup as the Elaborate section along with student-created code.



Task Requirements:

1. Students will run their code from the Elaborate section.
2. After the first set of wheels are put on the car, ORA moves to the Initial Position, and Evo signals that it is safe for human workers to be in the area.
3. Start a timer and time how long it takes for the human worker [student] to add the hub caps onto the car.
    a. Repeat the task 10 times for each person in the group
    b. The hub cap assembler should not move the car/fixture or that trial will be thrown out.
4. Students must answer the questions below.

Extension: Assembly Optimization Questions

1. What was the time for the fastest single time in your group?

[Depends on data collected]

2. What was the time for the slowest single time in your group?

[Depends on data collected]

3. What was the time for the fastest average person in your group?

[Depends on data collected]

4. What was the time for the slowest average person in your group?

[Depends on data collected]

5. What was the average time for your group?

[Depends on data collected]

6. What was the average time for all of the groups who did the extension challenge?

[Depends on data collected]

7. When performing the time trials, were workers more likely to bump/move the car/fixture since they were under a time crunch?

[Answers will vary, but likely, when students were rushed, they would be more likely to bump the fixture, causing the programmed positions and physical positions to be misaligned. Thus, everything will need to be reset and rerun.]

8. Are workers going to be able to maintain their fastest speeds over the course of a shift (8 hours)?

[Studies show the answer is no]

9. Knowing the range of speed of your workforce and that a bumped car/fixture means the whole run needs to be reset, what amount of time should ORA wait to allow for workers to safely place hubs without causing a reset, and why?

[Depends on data collected. But the number recommended should account for the slowest worker, including a little more time due to speed degradation over a shift. Students could also make recommendations to give training to workers to boost the overall average speed to increase efficiency.]