Challenge

Students will work together as a team to design two different robots: a harvest robot and a transport robot. The harvest robot will be a tree feller and stacker. The transport robot moves the logs from the field to the lumber mill. The goal is to cut down and move only the marked trees and transport them to the lumber mill as quickly as possible.

Materials Needed

- You will work together with another team to complete this challenge. One team will build the harvest robot, and one team will build the transport robot.
- Use one of these sets:
  - TETRIX® PRIME Programmable Robotics Set (44321)
  - TETRIX PRIME Dual-Control Robotics Set (44322)
- Items to create challenge field: painter's tape, materials to make paper trees, log yard, field of trees
- Engineering logbook

Objectives

By the end of the lesson, students will be able to:

- Design and build a challenge field.
- Build a robot within the constraints to meet the challenge.
- Write the steps and create a program for the robot that meets the challenge.
- Test and refine the robot program and design.
- Demonstrate the effectiveness of the robot to meet the challenge.
- Reflect and share on the challenge and its real-world applications.

Activity

Tree Harvester Challenge

Difficulty

Intermediate

Class Time

Six or more 45-minute class periods

Grade Level

- Middle school
- High school

Learning Focus

- Engineering problem-solving
- Robot assembly
- Computer science
- Encapsulating functions in coding

Step 1: Introduce (15 minutes)

- Share, define, and refine the challenge. Document this information in the engineering logbook.
- Write the challenge in your own words. Record the constraints you should follow, the materials that can be used for the solution, and what the testing field will look like. Discuss the constraints and materials that are allowed.

Step 2: Brainstorm (30 minutes)

- Brainstorm ideas to solve the challenge. Create quick sketches and describe solutions to the challenge.
- Considerations for your design:
    - The harvest robot needs the ability to move onto a field of trees, selectively harvest only the marked trees by pulling them out of the ground, and stack them for pickup by the transport robot.
    - The transport robot needs the ability to travel from the log yard to the stack of logs, load the logs onto the truck, take them to the log yard, and dump them into the drop box.

Step 3: Set Up (15 minutes)

- Build the challenge field following the pictured guide.
    - The challenge field should include a field of trees, about 120 cm x 120 cm marked by tape on the floor, with:
        - Paper trees, each about 3 cm in diameter and 8 cm tall.
            - Six should be light colored (white is best) and are to be harvested.
            - Four should be dark colored (black is best) and are not to be harvested.
        - A designated log-stacking location; how the trees are stacked is up to each team.
    - The challenge field should include a log yard, about 60 cm x 60 cm marked by tape on the floor, with:
        - A log drop box that is about 30 cm x 15 cm x 30 cm tall and is at least 150 cm away from the tree field.
    - The challenge field should include a road from the field of trees to the log yard. The road should wind around, be about 20 cm long, and be marked by tape.
    - Each team should design and build its own log-holding devices: one placed in the log yard (drop box) and one placed in the field of trees (field stack). These devices may be placed anywhere within each area that the team decides is best for their solution.

Constraints

The team's robots must:

- Contain parts from only one set.
- Measure less than 40 cm x 40 cm x 40 cm.
- Be able to perform the functions of their designated roles.
- Begin at the start area and take a maximum of four minutes to complete the task and return to the start area.

The harvest robot must:

- Locate the trees.
- Determine whether a tree should be harvested.
- Have an arm to pull trees from the ground and stack them.

The transport robot must:

- Stay on the road.
- Have an arm with the ability to load and unload trees.

- Scoring:
  - +20 points for each marked tree harvested
  - +10 points for each marked tree delivered to the log yard before the time is up
  - +10 points for each marked tree placed on the stack
  - +10 points for each marked tree stacked on the transport robot
  - +20 points for each marked tree placed in the drop box in the log yard
  - +30 points for each robot that makes it back into the start area before the time is up
  - -20 points for each unmarked tree pulled from the ground or knocked down
  - -40 points for each penalty incurred – for example:
    - The transport robot assists the harvest robot to collect logs.
    - The harvest robot assists the transport robot to transport logs to the log yard.
    - A robot does not leave the start area.
    - The team does not move at least one log onto the stack.
  - Score = points minus total time in seconds

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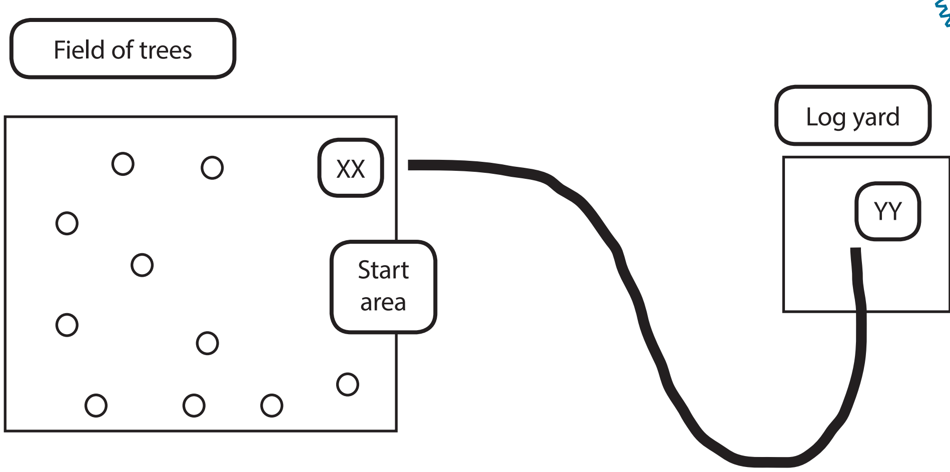
Possible Challenge Field



XX = possible location of field stack inside tree field
YY = possible location of drop box inside log yard

Step 4: Plan (30 minutes)

- Before building, think about the potential design of the robot and draw or record ideas in the engineering logbook. Consider the following:
    - Drivetrain and chassis for each of the robots
    - Field stack and drop box
    - Harvest robot manipulator
    - Transport robot accumulator
    - The harvest robot will need an Ultrasonic Sensor to locate the trees, a Line Finder Sensor pointing toward standing trees to determine whether a tree should be harvested, and an arm to pull trees from the ground and stack them.
    - The transport robot will need a Line Finder Sensor facing down so that it stays on the road and an arm with the ability to load and unload trees.
- Create a detailed sketch of your selected solution to the challenge. Label the materials you will use. Write a detailed description of how your solution meets the challenge, constraints, and criteria.

Step 5: Create (45 minutes)

- Design and build the robot. Remember to update the solution in the engineering logbook as the design is improved.
    - **Note:** The creation of the robot could take longer depending on the complexity of the robot solution.

Step 6: Write the Steps (15 minutes)

- Think through the steps or series of actions that the robot will have to complete to meet the challenge. Planning this series of steps is sometimes referred to as creating pseudocode for your robot.
    - Record these steps in the engineering logbook and use them as a guide when operating the robot. Notice that the steps are like writing code for the robot to follow. Make sure the robot performs all the steps required in the challenge.

Step 7: Create the Program (45 minutes)

- When you have completed this process, you are ready to begin programming using your steps as a guide. Remember to track changes in the engineering logbook.
    - When you are coding your robot, it is recommended that you write the code using functions so that each task can be tested and adjusted before it is incorporated into the final program.
- Prepare functions to control your robot, depending upon your solution plan.
- Check each function as you write it to make sure it works as you intend.
- Now, write a test sketch to try them all out.

Sample Steps

Harvest Robot:

1. Drive forward.
2. Locate a tree.
3. Identify whether the tree is to be harvested.
4. Pull up the tree.
5. Place the tree on the field stack.
6. Repeat until all marked trees have been harvested.
7. Return to start area.

Transport Robot:

1. Pick up the tree from the field stack.
2. Follow the road to the log yard.
3. Drop off the tree at the drop box.
4. Repeat until all marked trees have been transported.
5. Return to start area.

Step 8: Test (45 minutes)

- Test the solution. Place the robot into the challenge field and press the Start button to execute the code.
- Refine the solution. Adjust the design and code as needed. Document any changes in the engineering logbook.

Step 9: Demonstrate (15 minutes)

- When the robot has been tested and successfully navigates the challenge field, demonstrate its performance in a final test.

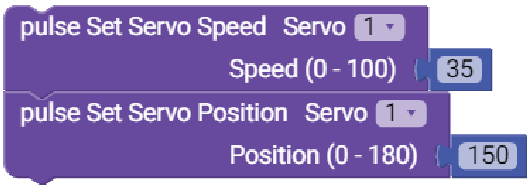
Step 10: Reflect and Share (15 minutes)

- Look back at the prototype. How does it compare to the final design?
- Look back at the original steps. How do they compare to the final steps?
- Discuss the original prototype, the final robot code, the solution as implemented, and how this challenge applies to the real world of robot design and programming.

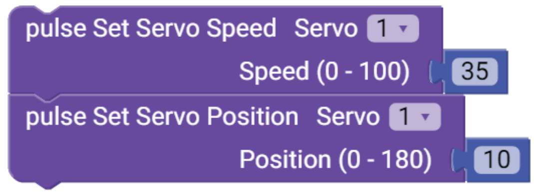
Step 11: Extensions

- Orchard-Harvesting Team
    - Try replacing the trees with small balls that are fruit of two different colors (black and white) and place them in rows randomly. The black fruit is ripe and should be picked. The white fruit is not yet ripe and should be left in the orchard. All fruit needs to be moved into the drop box without being dropped or smashed.
- Field-Planting Team
    - Change up the roles of the robots by creating a transport robot that picks up seeds (extra robot connector parts) from the storage area and brings them to the field, where it places the seeds into the hopper on a planting robot. The planting robot then moves onto the field and places the seeds a set distance apart (10 cm) in neat rows (25 cm apart) to cover the field.
- Field-Clearing Team
    - Randomly place boulders (wadded-up paper), trees, and trash (extra robot parts) on the field. Create a harvest robot that picks up all the objects in the field and places them into the dump truck. The dump truck must move the trees to the pulp mill area, move the boulders to the rock-crusher area, and move the trash to the recycling area.

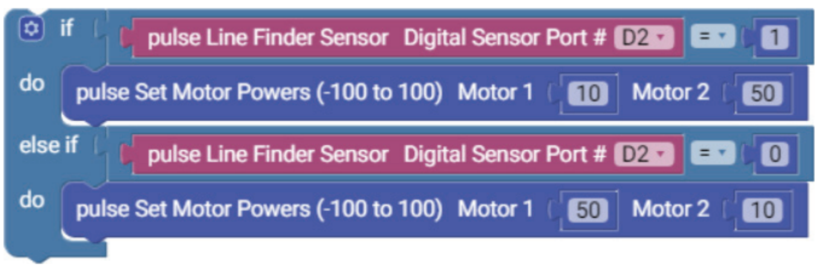
To get you started, here are some sample blocks for the PULSE™ controller with the *TETRIX Ardublockly* software.



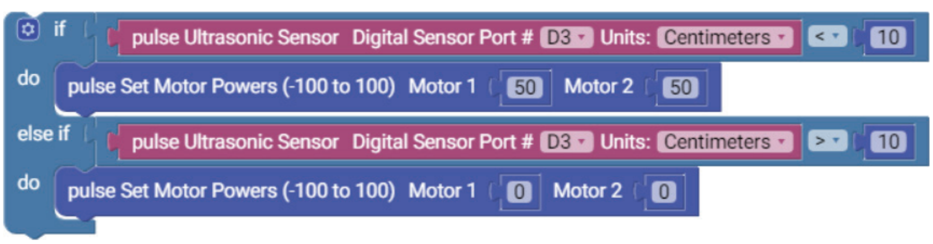
Open gripper



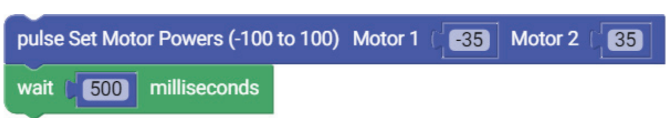
Close gripper



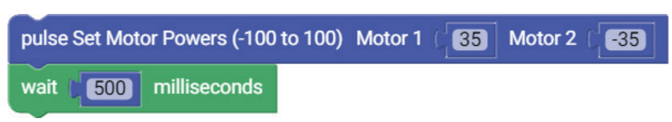
In this set of blocks, the robot will follow a black line.



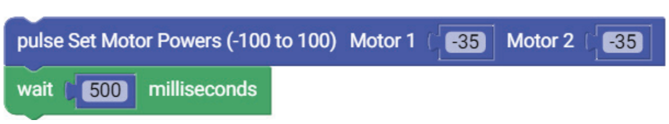
In this set of blocks, the motors will drive forward if the Ultrasonic Sensor detects an object less than 5 cm from it. If the Ultrasonic Sensor doesn't detect an object within 5 cm of it, the robot will stop.



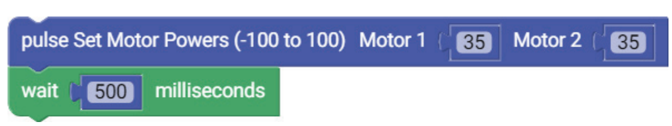
Turn left



Turn right



Go backward



Go forward