Challenge

Students will design, program, and build a robot that climbs the stairs to the top stair. The robot should climb, walk, or roll in some fashion to maneuver up steps and onto the top step.

Materials Needed

- 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, stairs
- 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

Stair Climber 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
- Center of gravity

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:
  - A robot that is too tall and narrow, or too short, could fall over when it tries to lift itself.
  - A high center of gravity might help the robot climb the steps.
  - The Line Finder Sensor should point down to follow the road.
  - You might need to use gears to create the upward movement.

Step 3: Set Up (15 minutes)

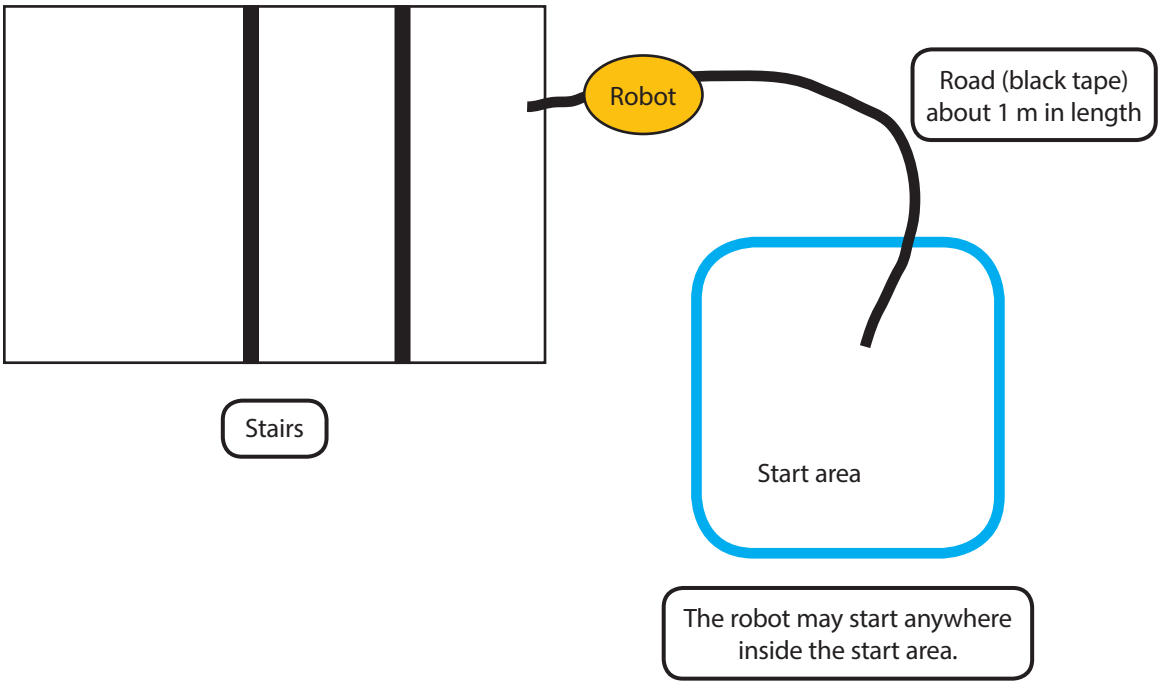
- Build the challenge field following the pictured guide.
  - The steps should have a rise of about 15 cm and a run of about 30 cm.
  - The top step should have a landing area with plenty of room for the robot to turn around – about 50 cm long by the width of the steps.

Constraints

The team's robot must:

- Contain parts from only one set.
- Measure less than 30 cm x 40 cm x 40 cm.
- Start from the start line inside the start area.
- Follow the road (the black tape lines) from the start area to the first step.
- Not leave any parts behind on the stairs. (For example, the team may not build a ramp, unless it is picked up by the robot during its run.)

Possible Challenge Field



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 for speed and control
  - Robot chassis for size
  - Movement that will vary the route up the stairs
  - Location and orientation of the Line Finder Sensor
  - Location and orientation of the Ultrasonic Sensor
- 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.

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.

Sample Steps

1. Follow the black line until I see the first stair.
2. Go up a stair.
3. Reset base.
4. Go up a stair.
5. Reset base.
6. Go up a stair.
7. Reset base.
8. Turn around carefully.
9. Celebrate.

Step 9: Demonstrate (15 minutes)

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

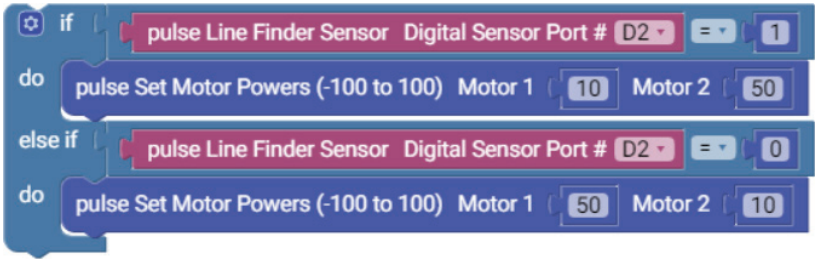
Step 10: Reflect and Share (15 minutes)

- 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.

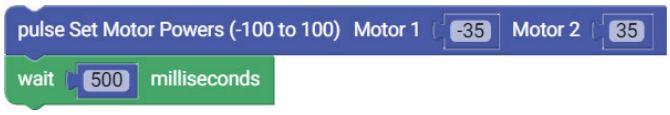
Step 11: Extensions

- Stair Helper
  - Use a small plush toy as a model of someone who needs help getting up the stairs. Have the robot pick up the toy in the start area, carry it up the stairs, and set it down carefully. Then, pick it up again and bring it back down the stairs.
- Coffee Mate
  - Have the robot carry a cup of water up the stairs and set it down without spilling it. You could use paper clippings, miniature marbles, or something else that is dry but that can be spilled from the cup instead of water.
- Treasure Hunter
  - The robot has 45 seconds to get to the top of the stairs, find the treasure (a small block, easily picked up, sized to reflect the Ultrasonic Sensor signal easily), bring it down the stairs, and deposit it into a bin (a small box).
- Real-World Stair Climber
  - Find the longest set of stairs in the building and have the robot climb them. Operate the robot on different sizes of steps.
- Piano Mover
  - Build the robot that can carry the heaviest piano (a stack of small books or masses from science mass sets) up a set of stairs.

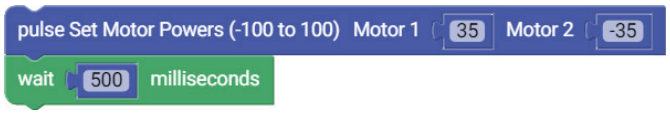
To get you started, here are some sample blocks for the PULSE™ controller with the *TETRIX Ardublockly* software.



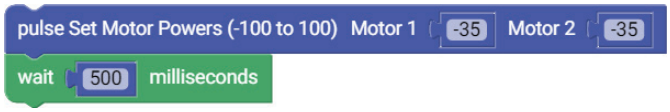
In this set of blocks, the robot will follow a black line.



Turn left



Turn right



Go backward

Go forward

Go in a circle