Challenge

Students will design, build, and program a robot that senses when a ball is rolled to it. The robot then collects the ball and rolls the ball back to the user.

Materials Needed

Each pair of students will create one robot.

- Use one of these sets:
  - TETRIX® MAX Programmable Robotics Set (43053)
  - TETRIX MAX Dual-Control Robotics Set (43054)
- Items to create challenge field:
  - Painter's tape
  - Balls of varying sizes (golf ball-size balls to tennis ball-size balls work best)
  - Tape measure or meterstick
- Engineering logbook

Objectives

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

- Build a challenge field.
- Write the steps for the robot to follow to complete the challenge.
- Design, build, and program a robot to meet the criteria and constraints of the challenge.
- Test, analyze, and refine the robot to improve its performance.
- Demonstrate the robot's effectiveness at meeting the challenge.
- Reflect on and discuss the challenge including its real-world applications.

Activity

Ball Returner Challenge

Difficulty

Intermediate

Class Time

Seven or more 45-minute class periods

Grade Level

- Middle school
- High school

Learning Focus

- Engineering problem-solving
- Sensors
- Programming/coding

Step 1: Determine the Challenge and Specifications (15 minutes)

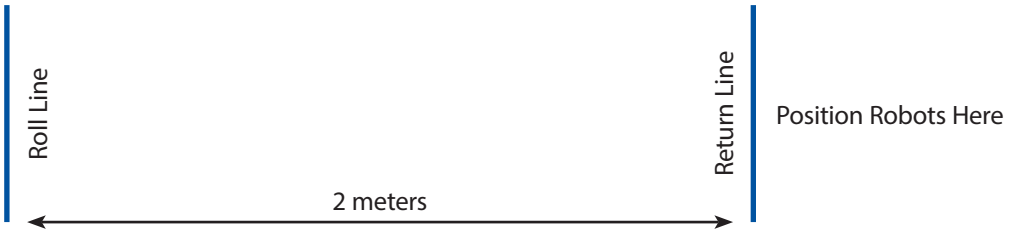
- Share, define, and refine the challenge. Ask questions to help you get a clear understanding of the challenge. Document this information in the engineering logbook.
- Write the challenge in your own words. Record the constraints you should follow, the materials that can be used for the solution, and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

Step 2: Brainstorm Solutions (15 minutes)

- Brainstorm ideas to solve the challenge. Think of as many possible solutions as you can in the given time frame.
- Considerations for your design:
  - How will the robot be able to sense when a ball has been rolled to it?
  - What kind of collection system will your robot use to move the ball into the return mechanism?
  - What kind of return mechanism will your robot use to roll the ball back to the user?
  - What are the trade-offs of using DC motors versus servos motors?
  - What design features would your robot need to have in order to return balls of different types and sizes?

Step 3: Set Up (15 minutes)

- Build the challenge field:
  1. Identify a location for the challenge to take place.
  2. Use a piece of painter's tape to mark the starting position from where a ball will be rolled toward the robot. This will be called the roll line.
  3. Measure a distance of two meters from the roll line and mark this location with a second piece of painter's tape. This will be called the return line. All robots must be positioned behind this line.



Step 4: Formulate a Solution (30 minutes)

- Consider the ideas you brainstormed in Step 2. Which of these ideas do you think will have the most success on the challenge field?
- Turn your best ideas into a design for your robot.
- In your engineering logbook:
  - Create a detailed sketch of your chosen solution to the challenge.
  - List materials you will use.
  - Write a detailed description of how your solution meets the challenge criteria and constraints.

Criteria and Constraints

The team's robots must:

- Utilize parts from only one set.
- Contain no bent, cut, or broken pieces.
- Be stationary.
- Be able to sense when a ball has been rolled to it.
- Be able to collect a ball that is rolled to it.
- Be able to roll the ball at least two meters in the direction the ball came from.
- Work with at least one of the differently sized balls that has been supplied.
- Incorporate at least one sensor, one servo, and one motor.

Step 5: Prototype the Solution (135 minutes)

- Build the robot according to the designs you created in Step 4. If you modify the design as you build your robot prototype, remember to change the design in your engineering logbook.
  - **Note:** The creation of the robot could take longer depending on the complexity of the robot solution.

Step 6: Develop a Process (10 minutes)

- Robotic challenges often require robots to complete a series of tasks in a certain order. This series of steps is called a process. Think through the process your robot needs to complete to be successful in the challenge. Planning this series of steps is sometimes referred to as creating pseudocode for your robot.
  - Record your robot's process in your engineering logbook. Use this process as a guide when operating the robot and completing the challenge.

Step 7: Program your Robot (45 minutes)

- When you have created your process, you are ready to begin programming using your process steps as a guide. Develop code for each of the tasks that your robot must complete. Remember to record important information and 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 as needed.
- When you're finished coding, verify the code and the upload the code to the PRIZM® controller on your robot.

Step 8: Test and Analyze (30 minutes)

- Test your robotic solution. Place the robot in your challenge field and, using the PRIZM controller, execute the program you developed in Step 7.
- As you test your robot, record observations and data in your engineering logbook. Determine if your robot meets the requirements of the challenge.

Step 9: Redesign or Improve the Solution (30 minutes)

- Refine your challenge solution. Adjust the robot design and program as needed. Document any changes in the engineering logbook.
- Make the physical changes to your prototype robot according to your design modifications.

Step 10: Demonstrate (15 minutes)

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

Sample Process for Returning Balls

1. Turn on and be ready to detect a ball.
2. Detect when a ball has been rolled and is ready to be collected.
3. Collect the ball and move it to the ball lifter.
4. Lift the ball onto the ball returner.
5. Dump the ball onto the return track so that the ball rolls down the track and back to the roll line.

Step 11: Reflect and Share (15 minutes)

- Reflect on the changes your robot went through from original idea to final design.
- Reflect on the results of the challenge. What elements of your robot design brought you success or failure?
- Discuss the roles and responsibilities each team member fulfilled. How did teamwork and collaboration help you complete the challenge?
- Discuss how this challenge relates to robot design in the real world.

Step 11: Extensions

- Differently Sized Balls
  - Modify the robot so that it can return different types and sizes of balls.
- Golf Putt Returner
  - Modify the robot to return golf balls that are putted into it. Create a section of the return area that represents the hole and use a sensor to detect and raise a flag when the putted ball goes into the hole.
- Discussion
  - Discuss what it would take to transform your ball returner into a shooter robot such as a baseball or softball pitching machine.