Challenge

Students will design and build a robotic crane that can lift a load to a height of 30 cm and then rotate and lower the load into an unloading zone.

Materials Needed

Each pair of students will create one robot.

- Use one of these sets:
  - TETRIX® MAX R/C Robotics Set (41990)
  - TETRIX MAX Dual-Control Robotics Set (43054)
- Items to create challenge field:
  - Painter's tape
  - Empty paint bucket or similar container
  - Meterstick
- Scale to measure mass
- Weighted material such as sand or gravel
- 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 and build a robot that meets 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

Crane Challenge

Difficulty

Intermediate

Class Time

Five or more 45-minute class periods

Grade Level

- Middle school
- High school

Learning Focus

- Engineering problem-solving
- Robot assembly
- Simple machines (wheel/axles and levers)

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 (20 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 can gear trains be used to increase the rotational torque on the lifting winch?
  - How can counterweight be used to balance the crane while lifting the load?
  - How will servos and DC motors be used to lift and move the load?

Step 3: Set Up (30 minutes)

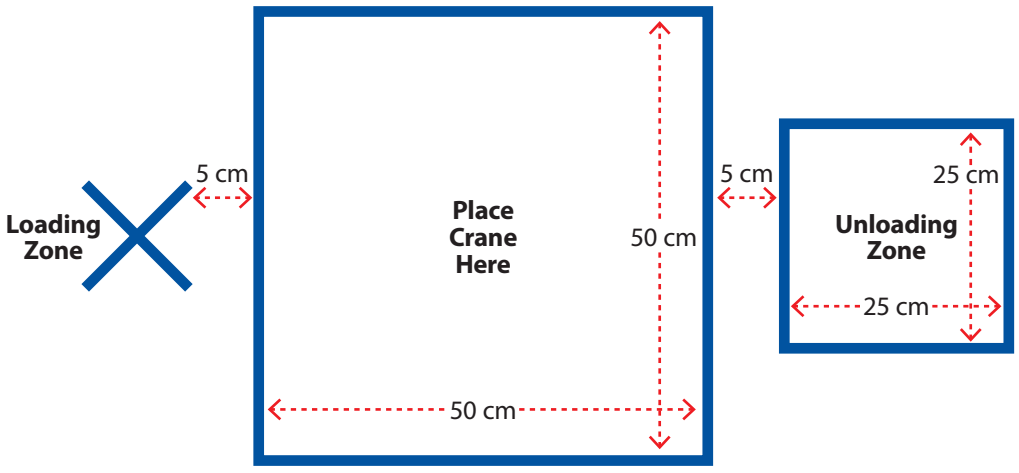
- Build the challenge field:
  1. Create a square box with painter's tape that is 50 cm x 50 cm. The base of each robotic crane must fit inside this box when completing the challenge.
  2. On one side of the box, create an X with painter's tape. This is where the bucket with the load will be placed to be lifted by each crane. Position the X so that when the bucket is there, the edge of the bucket is about 5 cm from the edge of the box.
  3. On the opposite side of the box, create another square box with painter's tape that is 25 cm x 25 cm. The edge of this box should be about 5 cm from the edge of the crane's box. This smaller box will be the unloading zone.

Criteria and Constraints

The team's robots must:

- Utilize parts from only one set.
- Utilize R/C components for controlling the robot.
- Contain no bent, cut, or broken pieces.
- Fit within a square that is 50 cm x 50 cm.
- Include a winch with string and hook that is used to lift the load.
- Be able to lift the load to a height of 30 cm.
- Be able to rotate the load 180 degrees while lifted.
- Be able to lower the load into an unloading zone.

Example Field Setup



Step 4: Formulate a Solution (20 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.

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: Test and Analyze (15 minutes)

- Test your robotic solution. Place the robot in your challenge field and follow the process you wrote in Step 6.
- As you test your robot, record observations and data in your engineering logbook.

Step 8: Redesign or Improve the Solution (45 minutes)

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

Step 9: Demonstrate (15 minutes)

- When the robot has been tested and successfully completes the challenge, demonstrate its performance in a final test.
  - Measure the amount of material moved with the scale.

Sample Process for Lifting and Moving a Load

1. Attach the load to the winch.
2. Use the winch to lift the load to a height of 30 cm.
3. Rotate the crane and the load 180 degrees.
4. Lower the load into the unloading zone.
5. Detatch the load from the winch.

Step 10: 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

- Lifting Competition
  - Hold a competition to see which team's crane can lift and move the heaviest load. Start with a light load. Each team must be able to lift the load to a height of 30 cm and move the load to the unloading zone. Conduct several rounds, adding weight each round. When a team's crane fails to complete a round by being unable to lift the load, that team is out of the competition.
- Simple Machines
  - Discuss what simple machines are being used on each team's crane. Calculate the mechanical advantage of each simple machine used on the crane. Then discuss how mechanical advantage can be maximized to improve the performance.
- Mobile Cranes
  - Have teams add a drivetrain to their crane so it can lift and transport loads over longer distances. Create a new challenge field where the unloading zone is some distance from the loading zone.
- Autonomous Cranes
  - Add a PRIZM® controller to the crane and program the crane to lift and move the load. Consider incorporating sensors to make the crane smarter.