

## Orchard Project - Lesson Guide

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Please note: the Orchard project requires students to use ROBOTC for progressively more difficult challenges from Phase 2 on. Students will be required at least to be able to navigate through the Programming/ROBOTC material to find the programming guidance they need. They will also need to keep in mind that the basic challenge in the ROBOTC material (navigating through a maze) is fundamentally different than any of the challenges they face in the Orchard project (even though certain aspects of the different problems are similar, and links are provided to similar material for convenience).

Teachers may wish to have their classes complete some or all of the ROBOTC material (Setup, Fundamentals, Movement, Radio Control and Sensing) as preparation for the Orchard project. They may also introduce some or all of the ROBOTC material prior to Phase 2, when students are required to program.

Teachers whose classes have more advanced programming skills, on the other hand, may wish to challenge their students to master the ROBOTC material while simultaneously completing the Orchard project, and will therefore not wish to teach the ROBOTC material separately and as a preparation.

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### Orchard Project:

The Orchard project is composed of two major parts:

In Lesson 1, students will research the role of automation technology in one sector of agriculture (pesticide spraying), and put together a presentation to a prospective client to secure funding to begin development.

Lesson 2 is an introduction to radio control, programming and sensors through a series of increasingly sophisticated prototypes of a mobile robot platform that can navigate the tight spaces between rows of trees in an apple orchard.

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### Lesson 1 - The Problem:

Students will take the role of consultant-developers at an automation company who are investigating whether a client in the agricultural supply business should invest in developing automation systems for their pesticide-sprayer fleet. Students must research the topic and deliver a presentation and proposal to the client for further development.

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### Lesson Duration:

2-3 class periods, 2 weeks total running time including research homework.

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### Objectives:

At the end of this unit, students will be able to...

1. Understand the motivations and arguments both for and against automation of agricultural processes in the United States.
  2. Present an effective proposal to a client in order to procure support for future development.
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### Required Knowledge and/or Skills:

Students should have a working knowledge of how to use their local library and internet resources to conduct research quickly on their own, or the lesson should be used concurrently with an activity that teaches about conducting such research.

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### How to Use the Lesson Materials:

1. Introduce assignment, which should run concurrently with other introductory material about engineering process, project management, or an introduction to the robotics technology being used in the construction of the prototypes for Lesson 2. It can also accompany a lesson on conducting research using library resources.
2. Discuss initial questions and considerations with class.
  - a. Consider your audience. What is an agricultural goods supplier interested in knowing? Keep your discussion relevant to your audience.
  - b. This would not be the first time a major improvement/change has been proposed to an existing industry or technology. How has this worked out in the past? In what ways is this discussion relevant to the current situation, and in particular, to your audience?
  - c. When discussing the advantages of the robot approach, your client will not be interested in how fancy or shiny your technology is, only how it will improve results.
  - d. You have more than one person on your team. Coordinate your efforts for maximum effectiveness.
  - e. Practice your presentation out loud, with your teammate(s) and your Powerpoint or poster.
3. Progress check every 2-3 days. Have students turn in rough drafts and outlines, or give presentations to small groups of peers.
4. Final presentation should be given on a set date. If desired, an outside observer can be brought in to play the "executive" from the client company.

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### Extension Activities:

1. Students may work ahead on Lesson 2, which involves the implementation of a prototype model of the robot that will carry the sprayer.
2. Students may do additional research (for example, an essay, report, or second presentation) on the labor-technology debate or the viability of United States agriculture in the global economy, and whether/how it is dependent on advanced technology.
3. Students may wish to organize an in-class debate on the merits of introducing automation in this scenario, in either a formal or town hall-style forum. Some students could play the role of displaced field workers or crop-dusters, while others could present the views of local residents (who may or may not have a personal stake in the orchard itself), and still others could act as representatives of an automation firm or an agricultural supplies company who is marketing the automated sprayer.

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### Classroom Preparation:

Standard classroom setup for student presentations. Optionally, an auditorium or conference room setting may be arranged for the final presentation. Volunteers from local industry can stand in as "executives" in the audience for the final presentation as well.

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### Lesson 2 - The Solution:

Students will develop a robot in four iterations that will be able to navigate the orchard successfully using progressively more advanced and reliable techniques. This lesson may overlap with Lesson 1, so that students use early iterations of their

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robot as “proof of concept” in their presentation.

### Lesson Duration:

2-6 weeks, depending on concurrency with Lesson 1 components, student programming experience, game board complexity, and the depth to which the teacher wishes to cover the programming principles embedded in the activity.

### Objectives:

At the end of this unit, students will be able to...

1. Design, build, and program a robot able to navigate autonomously or by remote control through a model orchard.
2. Evaluate a robot design and propose and implement improvements to it.
3. Strategize about the best way to accomplish a scored task within given resource and performance constraints.
4. Reflect upon, document, refine, and communicate with others about their design process.

### Required Knowledge and/or Skills:

1. Basic computer knowledge – manipulating and storing files and folders, how to use common on-screen interaction techniques (click, drag, etc.) and elements (buttons, dialog boxes, etc.)
2. Basic mechanical skills – how to use an allen wrench, twist ties, and how to plug things in to labeled ports/sockets

### Lesson:

1. Introduce assignment, which can be run concurrently or sequentially with the material in Lesson 1.
2. Students will build Squarebot 2.0 (the standard mobile robot for the Vex curriculum), or the original Squarebot from the Vex Inventor's Guide manual, or any other simple/stable design.
3. Assign students to drive the robot through the orchard challenge, potentially as a demonstration for the “client” (from lesson 1).
  - a. Robot must compete in the orchard challenge using only remote control and physical robot design elements (modifying the design for optimal performance should be encouraged).
  - b. No autonomous commands allowed.
  - c. No special board configurations.
4. Students will give a brief informal presentation/discussion on programming and design aspects that worked well for the remote control challenge.
5. Introduce the concepts of programming and behaviors.
6. Assign students to program the robot for phase 2 of its development:
  - a. Robot must compete in the orchard challenge using only timed motor commands and physical robot design elements to navigate through the aisles between rows of trees.
  - b. No remote control allowed.
  - c. No special board configurations.
7. Students will give a brief informal presentation/discussion on programming and

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- design aspects that worked well for the phase 2 challenge.
8. Introduce sensors (whichever types are available in that specific classroom).
  9. Assign students to program the robot for phase 3 of its development:
    - a. Robot must compete in the orchard challenge using sensor-informed behaviors and physical robot design elements to navigate through the aisles between rows of trees.
    - b. Timed motor commands allowed but discouraged. Use of more reliable sensor-based behaviors should be encouraged instead.
    - c. No remote control allowed.
    - d. No special board configurations.
  10. Students will give a brief informal presentation/discussion on programming and design aspects that worked well for the phase 3 challenge.

### Extension Activities:

1. Optional board modifications can be implemented in order to increase the difficulty of the challenge, or add a novel factor for students who may be getting tired of the basic challenge:
  - a. As a safety precaution, the robot must come to a full stop on its own if a human (any action figure or doll-sized model will do) steps into the robot's path while it is running, or if any other obstacle (fallen tree) is detected. It should resume normal operation after the obstructing object (human or otherwise) is removed.
  - b. The robot would be best operated under human supervision during the day, and autonomously at night. Using a light sensor that can detect the ambient room lighting (i.e. classroom lights), the robot should switch into remote control mode during the day (lights on), and automatically switch into autonomous mode at night (lights off). Discuss whether this is a suitable method for detecting day/night in the real world.
2. Students may keep a more extensive record of their design process. For instance, they may create a website documenting their progress, or use defect-tracking software to manage their robot issues.
3. Students may make a formal presentation of their process and progress at project's end.
4. Robot design and manufacturing aspects can be combined with CAM/CAD instruction, allowing students to model their physical robot in virtual space, and create animations, plans, schematics, or find other uses for the model.

### Classroom Preparation:

Required (per group):

1. 1 Vex Starter Kit or equivalent
2. 1 Programming Kit
3. 1 PC with ROBOTC installed (for programming)

Recommended:

1. A walled game board, 8' long and 4' wide, with segments of PVC pipe to simulate trees in the orchard. Approximate materials cost is \$50 (one-time expenditure, board is reusable for other activities). Building instructions are provided.
2. Additional sensor accessory kits. Optical Shaft Encoder, Line Tracking, and Ultrasonic Rangefinder kits can be of great use in this and other lessons.

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### Safety

Standard lab safety procedures should be used. Safety goggles should be worn. Additional safety precautions should be taken as appropriate if machine tools are being used to cut, bend, or otherwise modify kit parts.