Note to the Teacher

Engineers, like all other workers, need to be able to work with others. The projects in this section are designed to give students the opportunity to work in teams. Upon completion of the Engineering Activities section of this curriculum, students will be able to:

1. Function on multi-disciplinary teams
2. Communicate effectively using all forms of verbal and non-verbal expression
3. Describe various methods used to manage and schedule projects
4. Participate in and conduct design reviews
5. Identify, formulate solutions for, and solve engineering problems using engineering design processes

There are several common threads that are interwoven throughout each activity: engineering process, project management, communications, and teamwork. In each activity, students will be given a problem, a finite set of resources, and a limited amount of time. They must then develop and implement their own plans to solve the problem. The understanding and effective application of engineering processes and techniques are essential to the successful completion of the project within the given constraints. At the end of each project the teacher needs to debrief with students. Take this time to discuss what worked and what didn't work on their teams, and be sure to review project management strategies. It is recommended that new teams are made at the end of each engineering problem.

It is important to hold the class to assigned due dates, especially during the first project. If you extend the due date, students will expect the same in the future. In addition, most students will take as much time as you give them to solve the problem. Help students to manage their projects by introducing project scheduling techniques, such as PERT charts and GANTT charts. If you would like project management handouts, you can find them in the Project Management section of the curriculum.

The Engineering Activities portion of the curriculum is divided into five engineering activities:

- The Rube Goldberg Challenge this design challenge has two parts: a typical Rube Goldberg Challenge and then a variation of the challenge which allows students to use a combination of remote control and autonomy to create a perpetual motion machine.
- The Orchard Challenge – The Orchard challenge consists of multiple parts:
    - Introduction – students take the role of consultant developers at an automation company who are investigating whether their client in the agricultural business should invest in developing automated systems to spray pesticides.
    - Phase one – Students will develop a robot in four different iterations that will be able to navigate the orchard successfully. Phase one is remote control.
    - Phase two – Basic autonomy driving straight and turning
    - Phase three – Sensor autonomy using feedback loops
    - Phase four – Enhanced Autonomy demonstrating obstacle detection as well as shared control.
- The Hot Dog Maker Design Challenge - In this challenge students are challenged to develop an automated system using the VEX Design System to automate a hot dog shop.
- The Automated Work Cell – The automated work cell combines the advanced features of the VEX system to complete a system that incorporates relays, PWMs, pneumatics, and other technologies available to the team. This is an advanced engineering design challenge.

Note to the Teacher

- VEX Competitions – provides a link to Carnegie Mellon's Robotics Academy were there are links to many VEX robotics competitions, some that can be implemented by a teacher in their classroom and others that are both regional and national in nature.

SELECTION CRITERIA (TO HELP YOU PICK WHICH PROJECT IS BEST FOR YOUR CLASSROOM)

Project	Time Required (Approximate)	Experience Level	Other Requirements	Focus/Coverage
Rube Goldberg	1 week class (mostly homework)	Introductory		**Focus**: Engineering process, teamwork, communication, systems concepts (input, output, subsystems, state), design **Coverage**: Non-Vex building of stationary "cells" in a system that can only perform their functions once, and do not have electronic control
Sweet Apple Orchard Project	8-10 weeks	**Recommended:** Students must know how to program with sensors	**Required:** Programming kit **Recommended:** Additional sensors	**Focus:** Technology and society, engineering process, teamwork, communication, design, programming, behaviors, sensors **Coverage:** Automation technology in societal context, PowerPoint presentations, environmentally constrained design, remote controlled motion, sensorless automated motion, sensor-informed automated motion
Hot Dog Maker Challenge	4-5 weeks	**Required:** Students must know how to program with sensors	**Required:** Programming kit, various additional sensors, hardware and tools	**Focus**: Engineering process, teamwork, communication, collaboration, systems concepts, reliability **Coverage**: Inter-team collaborative design and Vex building of subsystems that must work together reliably to accomplish a multi-step process with dissimilar functions at each step. Project management on several levels is key to successfully completing this activity.
Automated Work Cell	4-5 weeks	**Required:** Students must know how to program with sensors	**Required:** Programming kit, pneumatics kit, various additional sensors, hardware and tools	**Focus**: Engineering process, teamwork, communication, collaboration, systems concepts, reliability, pneumatics **Coverage**: Inter-team collaborative design and Vex building of subsystems that must work together reliably to accomplish a multi-step process with dissimilar functions at each step. Project management on several levels is key to successfully completing this activity.

Notes on Projects:

1. Rube Goldberg Challenge – No VEX parts, all recycled parts. Can be done at home as a homework assignment over the weekend and then brought to class. There are many examples of Rube Goldberg Machines on the Internet.

Note to the Teacher

2. Sweet Apple Orchard Project – Composed of two parts: a proposal/ presentation to the client, and a multi-phase development of a VEX prototype to navigate the orchard. Parts are not strictly bound to each other, and can be separated if necessary for time.
3. The Hot Dog Maker & Automated Work Cell – The nature and themes of these projects can be modified however the teacher sees fit (hot dog maker and work cell are just two ideas), and should be designed to fit available resources. The idea behind the projects is to challenge the students to develop an automated system that requires every group to be doing something different, yet integral, to the final solution. The solution to the system is up to the students.

Project Preparation

Teaching engineering (project management, teamwork, and problem solving) is an iterative process, just like engineering. The suggested sequence to teach this skill development is:

1. Introduce students to engineering (Engineering Process Video, What is Engineering PowerPoint, Definitions of Engineering PDF)
2. Introduce engineering process (Engineering Process PDF)
3. Require that students turn in plans (Project Planning)
4. Require students to work in teams (Working in Teams PowerPoint, Engineering Activities)
5. Teach students to respect each other (Project Management/First Team Meeting PDF)
6. Give students ample opportunities to solve new problems (Brainstorming PowerPoint, Engineering Activities)
7. Require evidence of project planning “Time Management” and GANTT Charts (Project Management/Time Management/GANTT Chart PDF). Pass the sample chart out for students to keep in their notebooks.
8. Demonstrate how to break a project into manageable parts, assigning deliverables, and self assigning due dates
9. Teach students how design reviews work.
10. Invite others in to review student solutions.
11. Require project documentation
12. Iteratively test solution
13. Give students the opportunity to present their solution
14. Debrief, talk about what worked, what didn’t work, and how to improve the process.
15. Give students other problems to solve - The students will improve each time they participate in the engineering design process. The first project may be a disaster for some teams. The debrief session is the most important part of the above process for new learners. Students need to recognize that this process will be with them in some form for the rest of their lives and so it is important that they become good at it.