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Robotics Engineering Curriculum 1 (REC1)

Unit Overviews

This section gives a brief overview of each Unit, describing the topics covered and outcomes for the student. The material is taught in a step-by-step fashion, that assumes no prior knowledge of robotics by the student. Basic robotic concepts are introduced in sections labeled “Core”. Each core section is immediately followed by an activity or project to reinforce the materials introduced in the core. Each section in the curriculum builds upon the knowledge gained in the previous sections.

All of the activities and projects are leveled either Fundamental or Advanced. The fundamental activities are written for a student with a 9th or 10th grade math and science skill set. The Advanced activities are written for a student with an 11th or 12th grade math and science skill set.

The fundamental activities walk the student through some of the more difficult math and science concepts that they may not have yet been introduced to the student. It breaks these concepts down into simpler components for the student to understand and relate too. The advanced activities move at a faster pace and are more challenging, assuming the student has a higher math and science skill set. Both the fundamental and advanced activities and projects teach the exact same materials. The teacher must determine which level their class should follow. Some teachers may choose to mix the leveling in the class depending on the grade level of the students.

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Unit 1 - Introduction to Robotics

Unit 1 introduces the student to the world of robotics. It reviews fundamental robotic terms and concepts required throughout the course. The student learns about the engineering design cycle and how to record information into an engineering notebook. An entire section in Unit 1 is dedicated to robotic safety in the classroom.

As the student progresses through the unit, they will be constructing their first Vex robot, the BaseBot. They will learn how to use basic assembly tools as well as how to identify available Vex robotic components from the classroom inventory system. The BaseBot construction is broken down into subsystems like chassis, drive train, wiring and wireless control.

After the robot is constructed, the students test and troubleshoot their creation. They learn how to operate their robot using wireless control in both Arcade and Tank style.

The final project challenges them to draw their initials on the playing field using the Basebot and a dry erase marker

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Unit 2 - Introduction to Vex Programming

Unit 2 introduces the student to programming. EasyC, the block style programming language for Vex, is introduced and will be used throughout the course.

The student is shown the differences between operator control of the robot and autonomous control. The student learns how to connect the BaseBot to the computer and control it via an Online Window in easyC. Students are challenged to create pseudo code for their programs before trying to create real programs in order to better understand the concept of programming flow.

Fundamental programming concepts like loops, statements, variables, constants and assignments are reinforced with activities and worksheets. Students learn how to create simple programs to command the robot to go forward, backward, left and right. They learn how to simplify their code using functions.

In the final project, students are required to make an unstable robot drive without tipping over.

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Unit 3 - Physics and Robotics

Unit 3 is the longest unit in the first semester as well as the most academic. It reviews many fundamental physics concepts such as speed and torque and shows how they apply to robotics.

Students will learn about motors and how they are used in robotics. Time is spent testing the Vex motors on the Basebot and logging performance information into the engineering notebook for future use. Topics like angular velocity, linear motion, gear ratios, weight, friction, torque and acceleration are all introduced and reinforced with activities related to robotics.

The final project challenges the student to pull a weighted sled 1 meter with the BaseBot. The BaseBot can be modified to take advantage of concepts learned within the unit.

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Unit 4 - Sensors

Unit 4 introduces the student to open- and closed-loop robotic navigation using sensors. This unit builds on the dead reckoning programs constructed in Unit 2.

Digital bumper switches are added to the BaseBot so that it can interpret its environment autonomously. An ultrasonic range-finding sensor is introduced to allow the robot to sense its environment without touching it, and a line-following sensor is used to make the BaseBot follow a line on the playing field autonomously.

In the final project, several binders are standing on end and the robot must autonomously find and knock down each binder in the specified time period.

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Unit 5 - Arms and End Effectors

Unit 5 combines the elements introduced in Unit 3 & 4. An arm is added to the BaseBot and a basic physics analysis is done on how the addition of the arm affects the overall robot design.

Center of gravity and its importance to robotic design is introduced. Stall torque is examined on the arm as well as the speed and gear ratio.

The student is challenged to incorporate two limit switches into the design of the arm to control the movement of the arm. This requires the student to create an easyC program to map the input from one of the channels on the transmitter to the motor on the BaseBot controlling the arm. An end effector is added to the end of the arm on the BaseBot using a servo motor to control the gripping range of the end effector.

In the final activity, the student must program the BaseBot to drive on the playing field and retrieve a ball while being controlled with the radio control.

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REC Unit 6 for Cortex: REC 1 Project

This is a two-week project that reinforces all the materials covered in Units 1 – 5.

The student must create a robot that can follow a line, pick up rings from the playing field, drop the rings off at a specified location and return back to the starting position.

At the end of the first week, a competition will be held for the class. Students will be required to navigate the course and perform the task with their robot under operator control. At the end of the second week, another competition will be held. This time the robot must complete the entire task autonomously, with no user input.

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Robotics Engineering Curriculum 2 (REC2)

Overview

This section gives a brief overview of each unit, describing the topics covered and outcomes for the student. The material is taught in a step-by-step fashion that assumes some knowledge of robotics by the student, and familiarity with the topics covered in REC 1. Robotic concepts are introduced in sections labeled “Core”. Each core section is immediately followed by an activity or project to reinforce the materials introduced in the core. Each section in the curriculum builds upon the knowledge gained in the previous sections.

Some of the activities and projects are leveled as either Fundamental or Advanced. The Fundamental activities are written for a student with a 9th or 10th grade math and science skill set. The Advanced activities are written for a student with an 11th or 12th grade math and science skill set. The Fundamental activities walk the student through some of the more difficult math, science and programming concepts that may not have been introduced in the classroom. The Advanced activities assume the student has a higher math and science skill set, are more challenging and move at a faster pace. Both the Fundamental and Advanced activities and projects teach the exact same materials. The teacher must determine which level their class should follow. Some teachers may choose to mix the leveling in the class depending on the grade level of the students.

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Unit 7 - Introduction to Electronics

Unit 7 introduces students to both the theory behind and the practice of basic electronics, one of the major facets of Robotics Engineering. Assuming no prior knowledge of electronics, the unit begins with a basic review of safety around electronics, the concepts of voltage, current and resistance, as well as how to read and create electronics diagrams. Students use real components and their own breadboard to create increasingly complex circuits. Additional topics in Unit 7 include a discussion of Ohm's law, series and parallel circuits as well as more complex components like transistors, potentiometers, photoresistors, timers and logical gates.

In the unit project, students incorporate programming on the Vex Controller with an electrical circuit on a breadboard to control a bank of LEDs.

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Unit 8 - Mechanical Properties

Unit 8 reintroduces the student to working directly with Vex. Students first learn about chain and sprockets with the new chain and sprocket kit, available in the REC 2 bundle. They then build a fast, durable, four-wheel drive robot called the "Tumblebot".

After building the robot, students learn about some of the advanced features of easyC V4, such as the Switch and Case function blocks, support for more sensors, and robot mapping. Students learn to write their own C functions and even type the code by hand into the new text editor. Students will finally learn how to program their robots for autonomous robotics competitions.

The capstone project for Unit 8 is a freeze tag competition where all of the students compete to see who can program and control their robot the best, while using everything they have learned in Units 7 and 8.

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Unit 9 - Advanced C Programming

Unit 9 reviews a number of advanced programming concepts that are applicable to both C and other programming languages. The first three Cores and Activities are dedicated to teaching the students PID (Proportional, Integral and Derivative) control. Students learn both the theory behind PID and practice using their Tumblebots equipped with a front mounted ultrasonic sensor. Students then learn other advanced programming techniques, such as filtering out erroneous data retrieved from a sensor, using arrays, behavioral robotics, encoders, and creating their own random number generator.

The final project in Unit 9 is a free design and programming activity where the students design, build and program their own “vacuuming” robot. All of the programming techniques taught in Unit 9 are designed to be both relevant to robotics, as well as other real life applications such as process control and manufacturing.

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Unit 10 - Introduction to Industrial Robotics

Unit 10 combines elements of Units 8 and 9 in the study of industrial robotic arms. Students first learn about the different types and uses of robotic arms and robotic systems in industry. The students then work system by system to create a fully functional three axis robotic arm using Vex mechanical parts and sensors, including the new potentiometer available in the REC 2 bundle.

After learning about the various ways to move a robotic arm, students combine a motor and potentiometer to simulate the operation of a servo. In the final project, students add conveyor belts to their robots and work together to pass an object from one robot to another, mimicking a real manufacturing environment.

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Unit 11 - Advanced Mechanics

In Unit 11, students learn about various advanced mechanical systems. In the first Core and Activity, students learn about and create a chain driven lift mechanism and use a spring scale to measure the force delivered by their lift. The next section discuses different types of gears, such as worm, bevel, and helical gears as well as rack and pinion systems, differentials and transmissions. In the activity, students build two sets of rack and pinion lifts and test them to see how much each can lift.

Students also learn about the uses for collectors and roller systems in both robotics and industry. With all of these advanced mechanics under their belt, students are now ready to complete the REC 2 project.

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Unit 12 - REC 2 Project

This is a two-week project that reinforces the programming and engineering concepts covered during REC 1 and 2. The student must design and build a robot that can compete in Bucket Battle, a game developed especially for REC 2 and intended to simulate the experience of real robotics competitions. Students must present a preliminary design to their teacher before building, and end the project with a critical design review, in which they present their various design considerations, strategies and mathematical calculations.

In Bucket Battle, the team with the fewest balls at the end of the match wins. Each team or alliance must frantically collect balls from their side, and dump them over the wall onto their opponent's side in order to keep their score low. The game begins with a 15-second autonomous period, during which robots can drop special balls into a large bucket to secure points. This game was designed to incorporate all mechanical, electrical and programming aspects taught to the students throughout the year in an exciting and competitive environment.

Teacher's Resources

The Teacher's Resources consist of a collection of all of the handouts and worksheets from the entire semester. You can also access the supplementary materials such as worksheet answers, and activity a guide containing tips, advice, and answers to each activity.