4 VEX Robot

Module Goal

The purpose of this module is to introduce the student to the VEX robotic system and allow the learner to construct a working robot using a VEX kit.

INTRODUCTION

Learner will be able to:

- Provide an overview of the VEX robotic system
- Identify Robot C interface
- Define sensors
- Given the specifics, build a robotic system using the VEX kit (Create POE Test bed)
- Expand upon programing the VEX robot

OVERVIEW OF THE VEX ROBOTIC SYSTEM

Types of Chain Drives

There are 5 subsystems that make up a robotic system.

Structure – foundations, mounting material, hardware
Motion- motors, servos, wheels, gears, sprockets and chains
Power- batteries, power supplies, chargers
Sensors- switches, push buttons, line tracking, encoders, potentiometers, ultrasonic light sensors
Logic- microcontrollers, wiring, programing

The structure subsystem

The structure of the robotic system is similar to the skeletal system of the human body.

Mounting material + metal components + hardware = the skeleton or frame

Fixed connections and connections that allow movement are combined in order to allow robotic parts to move as they are intended.

Introduction – Motor System

The motor system is made up of components that provide mechanical motion to the robot. We will discuss:

The transfer of energy
Motor features
Servo motors and gears
Common Measures

The motor subsystem

The following components allow the conversion of electrical energy into mechanical energy that takes place in the motor.
Gears
Sprockets
Chains

Identify the parts- gears

Find the gears on the subsystem below.
Hint: There are three of them!

Identify the parts-2wire motor
Find the 2wire motors on the subsystem below.
Hint: There are three of them!

Identify the parts-Motor controller
Find the motor controller on the subsystem below.

Identify the parts-2wire motors

The VEX Robotics kit includes a DC Motor which is referred to as a 2-wire Motor 269 or a 2-wire Motor 393.

These motors have the following characteristics:

Rotation – the shaft will rotate infinitely on DC power until power is disconnected
Polarity – the direction of the rotation depends on the polarity of the direct current applied
Conversion to 3-wire - both the 269 and 393, must be connected to the Motor controller 29 which converts the 2-wire connection into a 3-wire connection

Identify the parts-Servo motors and gears

Servo motors are used extensively in robotic systems. Although they are somewhat limited in motion and can only rotate with a specific 120 degree angle, servo motors are able to perform precise movements such as those required by pan/tilt cameras or steering in a remote control car.

Servo motors can operate backwards and forwards.

Identify the parts-Servo Motors

Find the servo motors in the image below.

Gears

Gear kits that are included in motion accessories will allow users to construct the combination that results in the correct torque, speed and direction for the needs of the system.

Click on the link below to learn more information concerning the gear kit.

http://content.vexrobotics.com/docs/inventors-guide/gear-kit-1-06-05.pdf

Introduction - Power subsystems

Power subsystems provide energy to various components. In this section, we will identify those components.

Power subsystems

Power subsystems provide electrical energy to all electronic components: the motors, microcontrollers, sensors, and controls.

Power sources include: Power supplies, batteries, and chargers.

Introduction - Sensor Subsystems

Sensors are used to translate the real world into electrical signals. The following slides will discuss digital and analogue signals.

There are two types of signals, *digital* and *analog*.

The **type** of signal is important when programming a robotic system so you know how the sensor will behave in any situation. Let's begin by discussing **Digital** signals.

Digital signals are characterized as having only **2 states.** Terminology used for 2 state digital signals is known by all of the following terms:

- **Boolean**
- **Binary**
- **Discrete**

The two states of digital signals are found in the formats below:

- true - false
- off - on
- 0 - 1
- high - low

Digital Signals

The topics that will be discussed include:
Input and Output
Signal Characteristics
Optical Shaft encoders

Switches and motors communicate via **digital signals**.

- Some devices are used to gather ***input*** for the microcontroller.
- Some devices are at the ***output*** end that ***receives*** and acts on the signals from microcontroller.

Digital Device	Signal Characteristics	Picture and link to vexrobotics	Input or Output
Bumper Switch / Tactile Sensor:	- simple, durable, pushbutton - used for avoiding large collisions - absorbs the impact and sends a HIGH signal to the microcontroller	Bumper Switch VEX Wiki	Do you think this fur input or output devic ○ **input** ○ output Correct! Or No, a bumper switc sends a signal ***to*** th
Limit Switch:	○ simple, highly sensitive pushbutton ○ actuated using very little force. ○ used in the applications of determining the limit position of an object.	Limit Switch VEX Wiki	Do you think this fur input or output devic ○ **input** ○ output Correct! Or No, a limit switch se ***to*** the microcontrolle
2-wire Motor:	○ controlled by a digital signal ○ signal is sent from the microcontroller through a motor controller that amplifies the signal (0-5volts) to match that of the motor. ○ each motor voltage is different	2-wire Motor 269 2-wire Motor 393 Motor Controller 29	Do you think this fur input or output devic ○ input ○ **output** Correct! Or No, a 2-wire motor *r* ***from*** the microcontr

Optical Shaft Encoders

Optical shaft encoders are composed of a disk with many slits evenly spaced around its outer edge. A fixed light **emitter** is mounted on one side of the disc and light **receiver** is mounted on the bottom side.

As the shaft holding the disc rotates, spaces between the slits block the light bean coming from the emitter to the receiver.

- These light interruptions create pulsing digital signal that can reflect measurements such as distance traveled, speed, and direction of motion of a rotary component.
- The signal is measured as an analog signal since it can measure a range.

Click on the link to learn more:

Optical Shaft Encoder VEX Wiki

Potentiometer

- Electrical resistor that is adjustable by rotating a shaft within 260 degree range
- Applied DC voltage produces a *voltage drop* that is measure as an analog signal with values between 0-5 volts
- Used to measure variations positions of components and input information into the microcontroller to act upon.

Click on these links to learn more.

Potentiometer Data Sheet

Potentiometer Wiki

Analogue Signals

We will learn:

The motors that are contorlled by analogue signal
The difference between analogue and digital signal

The following motors and motor controllers are controlled by analog signals.

Servo motors, discussed earlier in the lesson, are used for precise movements. Analog signals from the microcontroller direct the shaft of servo motors to a very specific location in a **range** between 0 and 100 degrees.

Motor controllers control the speed of the **2 wire motors**. The speed is received as a **PWM** Signal (**P**ulse **W**idth **M**odulation), a digital signal that pulsates at various intervals, depending upon if the signal is high or low. Because the PWM signal is represented as a *frequency*, it is put in the category of an analog signal since it can represent values *ranging* from 0-100%.

Servo Motor VEX Wiki

Data Sheet 3-Wire_Servo

Motor Controller 29 VEX Wiki

Unlike digital signals which are either “on” or “off”, analog signals can operate at *any* value between 0% and 100% at a given moment in time. In other words, analog signals and can register signals within a range of values.

An example:
An analog light sensor will measure between *0 to 1 volts* in a pitch black room, *4 to 5 volts* under normal room lighting, and *7 to 8 volts* under direct sunlight.

Based on these numbers we can make an assumption that the light sensor has a signal ***range*** of *0 to 10 volts*.

- 0% represents the minimum value the sensor can output,
- 100% represents the maximum value a sensor can output.
- Percentages can be anywhere between 0 and 100%.

Robotic systems make use of a variety of sensors and components that operate or function through the use of analog signals. These signals, as you remember, are used to control and measure a range of motions or frequencies.

The first two sensors we will cover are photo resistor-type sensors and ultrasonic range sensors.

Photo resistor-types ------------------------ Light Sensors

Ultrasonic Range –types ----------------- Sound or “Sonar” Sensors

“Photo” refers to light, and “sonic” refers to sound!

What makes these sensors analog devices?

Light sensors *measure the varying amount of light* in the environment. Light varies from darkness to sunlight in intensity, so light sensors must be able to read within a *range*. Analog signals measure ranges.

The analog signals from light sensors range in *output* voltage from 0 volts (no light) to 5 volts (bright sunlight). These signals are input into the microcontroller which is programmed to react in a specific way on given amounts of light sensed.

Ultrasonic sensors *detect sound frequencies above the range of human hearing*. Again, sound occurs in a range of frequencies, and so output signals must be stated within a range.

Which type of device is being described in the statements below?

- Resistors measure amounts and output signals in the form of *volts*.
  Ultrasonic sensor **Light sensor**

- This type of sensor measures the *distance* of an object from the sensor.

Ultrasonic sensor Light sensors

- The time lapse from the *emitter* on the device to the time the signal is *received* produces the measurement.

Ultrasonic sensors Light sensors

Light amounts can be measured by the amount of light that is detected on the resistor. Ultrasonic sensors are used to measure distance, much like a bat is able to do when it flies in the dark.

RESOURCES:

Click on these links to learn specific information about the sensors that you will be using in your classes:

Light Sensor VEX Wiki

Ultrasonic Range Finder Data Sheet

Other analog light sensors, like the line tracker sensor shown below add to the functionality of industrial robots.

Line Trackers

Line tracking robots, also known as line following robots operate in the following way:

- A sensor "reads" a black strip of tape on a white background
- Infrared light is beamed on a surface; the infrared sensor then detects the amount of reflected light.
- Sensors input that information about the location of the dark line to the microcontroller.
- The microcontroller sends commands to robot motors to turn one way or another, based on programmed responses to the light data it receives.

Click on the link to learn more about Line Tracking Sensors. Line Tracker Data Sheet

Logic Subsystem

In this section we will discuss the microcontroller and which components it controls**.**

A microcontroller is a small computer that can measure and/or send out digital and/or analog signals. All sensors and actuators are connected to the microcontroller to be read or controlled.

The program is a very detailed set of instructions that the microcontroller used to control the robotic components.

The **Programming Language** is a set of symbols and formatting techniques that describe the data collected by sensors,and what processes or transformation will happen as a response to the data.

Programming Language C++ is a version of language that the VEX Cortex Microcontroller understands. This type of programming language is also known as ROBOTC programming.

The **microcontroller** activates and controls the components of the robotic system based upon the input it receives from the sensors.

We learned earlier that the wiring and remote signals carry these commands to robotic controls.

Some of these controls exists as

- Remote controls
- Joysticks
- Pushbuttons

Programing

Topics:
Introduction to programing
Building a robot
Pseudo Code

Click on the button to learn more about what programing entails.
http://www.education.rec.ri.cmu.edu/products/teaching_robotc_cortex/fundamentals/introtoprogramming/thinking/videos/fundamentals1.html

To learn more about critical components of planning and behaviors in programing click here.
http://www.education.rec.ri.cmu.edu/products/teaching_robotc_cortex/fundamentals/introtoprogramming/thinking/videos/fundamentals2.html

To create a new file, first open the ROBOTC 4.X software and then click on “New File” to create a new program file.
Text functions
Program
Line numbers
Compiler errors

Designing the robotic system
The first thing to do when designing a robotic system is the find the problem that can be solved using robotics. The solution of the problem will be the robots objective.

The next step will be for you to write a pseudo code on the operation of the robotic system. Pseudo code is a written overview of the purpose and necessary steps to complete your task. When writing pseudo code, make sure to make a list of procedures you will need to achieve your objective.

Pseudo code for lifting a bottle cap:

Rotate arm 45 degrees from start position
open arm
close arm on piece
rotate arm up to 45 degrees to return to start positon

The pseudo code will provide an outline for you to follow when you start programing. The time you spend writing the pseudo code will save you time and frustration when you are writing the actual code.

Look over the sequence of steps that follow:

Mount the foundation, hardware, gears and wheels
Mount sensors, motors, microcontrollers
Write the sensors and motor controllers to the microcontroller

In order to program the robot, you will need to convert the pseudo code to ROBOTC syntax.

In organizing your program you will need to include the following:
declare variables
read outputs
write outputs
If else statements
while loops

Once you have written your code in the ROBOTC syntax check your work.

Download your program to your robot and make adjustments to your robotic system if necessary.

List the key terms that are required for the students to understand this topic and provide a definition.

Motor Subsystem Includes motors and motor controller used to actuate the robotic movements

Sensor Subsystem Translate input from light, sound, and touch to either digital or analog signals to control robotic components

Motion Subsystem Components that allow movement of the robotic components; composed of the motors, gears, sprockets, and chains

Microcontroller Small computer that can measure and/or send out digital and/or analog signals. All sensors and actuators are connected to the microcontroller to be read or controlled

Digital Signals Digital signals are characterized as having only 2 states, true or false. Also known as Boolean, discreet, digital, or binary signals

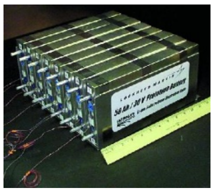
Analog Signals Analog signals exist in a range of values.

ROBOTC Programming language understood by the Vex microcontroller; a version of programming language C++

Available Resources:

OPEN SOURCE MATERIALS, include thumbnails for placement of each photo in MBL INTERACTION section above:

Name of Resource	Author/s	Source Location	License

File:NASA Lithium Ion Polymer Battery.jpg  **NO ATTRIBUTION**	JustinWick	http://commons.wikimedia.org/wiki/File:NASA_Lithium_Ion_Polymer_Battery.jpg	Public Domain
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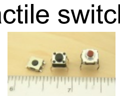
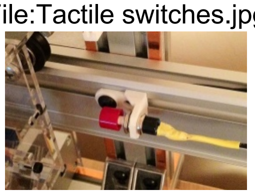
File:Tactile switches.jpg  **ATTRIBUTION:** "File:Tactile switches.jpg" by Scwerllguy is licensed by (CC BY-SA 3.0)	Scwerllguy	http://commons.wikimedia.org/wiki/File:Tactile_switches.jpg	Creative Commons Attribution-ShareAlike 3.0 Unported License
File:Tactile switches.jpg  **ATTRIBUTION:** "File:X50S FirePick limit switch.JPG" by Firepick1	Firepick1	http://commons.wikimedia.org/wiki/File:X50S_FirePick_limit_switch.JPG	Creative Commons Attribution-ShareAlike 3.0 Unported License

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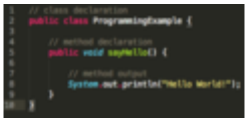 **ATTRIBUTION:** "File:Classes and Methods.png" by Bobbygammill is licensed by (CC BY-SA 3.0)			ShareAlike 3.0 Unported License
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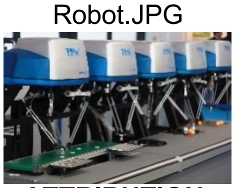
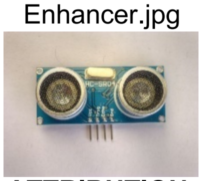
File:TOSY Parallel Robot.JPG  **ATTRIBUTION:** "File:TOSY Parallel Robot.JPG" by Humanrobo is licensed by (CC BY-SA 3.0)	Humanrobo	https://commons.wikimedia.org/wiki/File:TOSY_Parallel_Robot.JPG	Creative Commons Attribution-ShareAlike 3.0 Unported License
File:HC SR04 Ultrasonic sensor 1480322 3 4 HDR Enhancer.jpg  **ATTRIBUTION:** "File:HC SR04 Ultrasonic sensor 1480322 3 4 HDR	Nevit Dilmen (talk)	https://commons.wikimedia.org/wiki/File:HC_SR04_Ultrasonic_sensor_1480322_3_4_HDR_Enhancer.jpg	Creative Commons Attribution-ShareAlike 3.0 Unported License

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SUMMARY

In this lesson you have learned the basic subsystems that make up a robotic subsystem.

- structure
- motion
- power
- sensors
- logic systems

You've learned the setup, components, and techniques necessary for each of these subsystems, as well as the steps for writing and programing a robotic system in a lab.

STATEMENTS

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