MS4SSA

WPI

Introducing WPI MS4SSA Robotics Modules

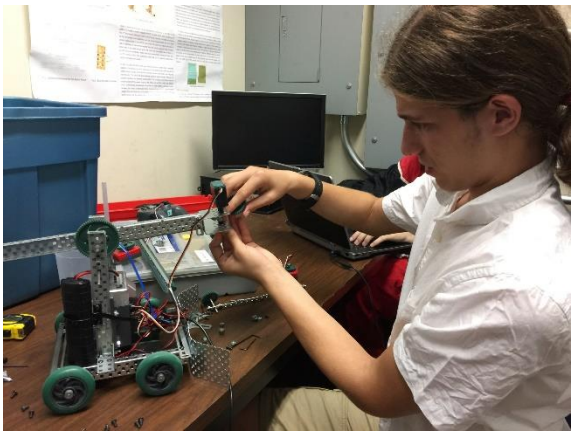
To access the modules, visit:

www.wpi.edu/+ms4ssa

Overview of Robotics Modules

The Robotics Education modules presented by WPI for the MS4SSA Program consist of the Programming and the Mechanics sections.

Mechanics:



Robots are machines or a system of mechanisms that work together, based on a set of algorithmic instructions, to complete a given task. Therefore, in this section of the robotics modules, we explore how a system of mechanisms is put together to achieve a desired set of tasks.

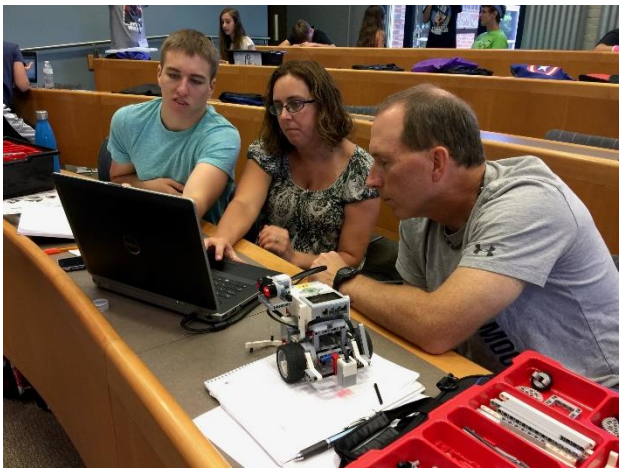
The Mechanics modules currently cover the following topics: Force Analysis and Power Transmission. These can be seen as the building blocks, which underlie any complex robotic system. In the Mechanics modules, we provide a gentle introduction to core concepts and pace their learning using formative quizzes. Using the project-based approach, students are introduced to practical examples, which enable them build intuition on the subject matter. The overall structure of the modules is designed towards practical implementation.

In Force Analysis, we present the methods for carrying out the analysis of loads (forces, moments) acting on physical systems (robots). These loads do not cause a resultant acceleration on the physical system, hence a state of static equilibrium is assumed. Students get an understanding of forces, moments/torques, coordinate systems, vectors and other pertinent concepts in conducting these analyses. Engaging as well as thorough labs are conducted by the students, which provide them a very intuitive understanding of the subject. Students are motivated to obtain the necessary knowledge as would be relevant in completing the final project (which could be a robotics competition).

In Power Transmission, we present the concepts of mechanical power transmission system that are used in controlling the power and performance of mechanical systems. Students get to understand how motors generate rotational motion from electrical energy and using power transmission systems, can manipulate the torques and speeds of the motors to meet their task requirements. Concepts such as gear ratios, torque ratios, motor power curve are presented. Various examples of transmission systems are considered such as spur gears, chains and sprockets, rack and pinions, etc. Lab exercises are utilized to help students get a practical feel of the material and then practical implementation in their project enables them apply the concepts directly.

We believe that these modules offer students with a unique opportunity to break away from the pattern of rote learning and actively engage with core engineering concepts in a practical and useful manner. Students turn out to be more confident in their understanding and abilities in designing mechanical systems based on this approach.

Programming:



The programming modules take students through a variety of computer science topics. We start with the very basic programs with simple loops and conditional statements and end with robot control for precise movement of actuators.

The first programming module exposes students to robot movement by driving the robot in various shapes such as circles and squares. These programs allow students to learn about loops and conditional statements and functions. By starting with these very simple programs, it engages students right away as they can see the robot driving around in preplanned directions that they specify.

The second module introduces students to sensors to enable precise control of their robot. The sensor used in this module is the ultrasonic rangefinder. With this sensor, you can determine the distance to objects in front of the robot. By writing simple programs such as stopping in a predetermined distance from an object students learn about simple robot control theory. The results of modifying parameters in their program becomes obvious with the operation of the robot. Once the students understand the operation of the rangefinder they can write programs to keep the robot from hitting obstacles by sensing them in front of the robot

The third module continues with the use of sensors by having the robot track lines on a table or floor. The students are required to characterize the operation of the sensors by measuring their outputs in a variety of circumstances. Having done that the students can write a program to stop on a line, follow a line using one, two, or three sensors to test for optimal performance. This is a good example where the students need to optimize their program for speed versus accuracy. Additionally students can explore other uses of the sensor such as detecting a cliff where the robot stays on a table without driving off a side.

These three modules just skim the surface of programming that can be learned using robotics. Additional modules will be provided for more advanced students that will allow them to dig deeper into programming concepts.

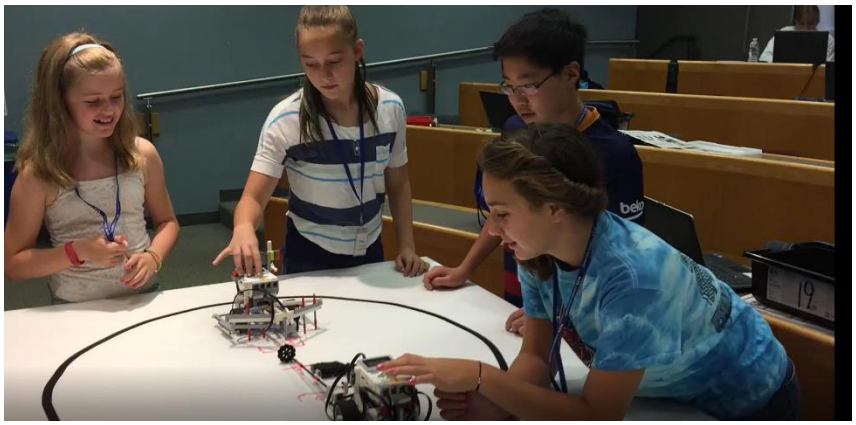
Learning Objectives:

Mechanics:

- Students get a clear understanding of the concept of kinematics - displacement, velocity, acceleration in both linear and rotational motion. They are able to perform simple calculations to derive kinematic values from simple robot systems.
- Students build basic intuition about kinetics concepts - forces and torques as they relate to robots.
- Students get a gentle introduction to force analysis. They are able to draw a simplified free-body diagram. They are able to perform basic analysis of forces on a basebot.
- Students get a gentle introduction to actuators - DC motors. They learn about power curves, current, voltage, electromagnetism, etc.
- Students are able to perform basic motor selection for robot systems based on simple design requirements.
- Students get a clear understanding of power transmission systems. They learn about gear/speed ratio, different transmission mechanism and build necessary intuition on how to design transmission systems for their robot.

Programming:

- Students learn to break down complex projects into simpler and simpler tasks to help understand how to use a top-down approach to solve problems.
- Students learn the basics of programming using the C language, which is used for embedded device programming by professional programmers.
- Students get a clear understanding of the operation of sensors by having to characterize their operation and observing the results.
- Students will learn how to debug programs that they write using the tools available in the Integrated Development Environment (RobotC).



Outline of Robotics Modules:

Module 1: Introduction to Robotics

- What are robots and how do they work?
- Inspiration behind learning about robotics; Applications of robotics in real life (in an African context)
- Components of robotics: programming, mechanisms, electronics

Module 2: Setting up the Vex BaseBot

- Walk through the process of assembling a basebot
- Understanding the core components of the Vex robotics kit: parts, sensors, motors, controller etc.

Module 3: Introduction to Programming

- How to translate human-understandable goals into C programs
- What are programs and what are the basic constructs used in C.
- Using the programming tools, in this case RobotC for writing, executing and debugging robot programs.
- Programming the robot to meet the specification provided in a presented problem.

Module 4: Using Sensors to control robot movement

- Learn about the Ultrasonic Rangefinder sensor to determine between the robot and other objects.
- How to characterize the sensor by understanding its operation and limitations.
- How to use the sensor to provide feedback on the operation of the robot.
- Developing a more advanced program that demonstrates an introduction to robot control systems.

Module 5: Line Tracking

- Learn about the Line Tracking sensor and how to characterize its operation to properly be able to use it.
- Develop a program that stops the robot as it crosses a line.
- Develop a program that uses a single line tracking sensor to follow a curved line.
- Learn how to improve the accuracy and performance of the program using an additional sensor.
- Learn about how to tradeoff speed for accuracy in a program.

Module 6: Introduction to Mechanics (Kinematics & Kinetics)

- What is motion? Linear and rotational motion?
- How to describe motion – displacement, speed, velocity, acceleration.
- What causes motion? Newton's laws of motion.

Module 7: Force Analysis

- Understanding forces and moments? Friction, vectors, coordinate systems, etc.
- Practice creating accurate free-body diagrams and calculating the associated forces and moments using equations of equilibrium (EOE).
- Determining the center of gravity (CG) of a body both analytically and experimentally.

Module 8: Actuation: Motors and Power Transmission

- What are motors and how do they work?
- Learn about DC motors, motor power curves, motor selection criteria.
- Learn about different power transmission mechanisms, gear ratios, etc.