Curriculum Overview

The FIRST® Tech Challenge Class Pack is flexible as a course that can be utilized in many different course pathways, including:

- Introductory to technology education courses in 7th or 8th Grade
- Intro to Engineering Course, and an Advanced level
- Applied engineering course you might have at the advanced level.

The course design has flexibility in the scope and sequence that enables you to customize it for your student’s needs. Scaffolding occurs within the curriculum to increase the ability to cover units at a basic level for beginner students and then have more advanced students dive into the math and science principles. You can find sample scope and sequence scenarios in this framework.

The course supplements middle and high school curriculums with essential design elements that include:

- Authentic Project-Based Learning with the following criteria:
  - Cross-curricular content in math, physical sciences, entrepreneurship, and language arts connections in communication in writing and oral presentation.
  - Unit projects help students build career skills and project management.
  - Project management
  - Implementation of culminating semester projects with robot competitions and sharing knowledge with others increase authenticity for students.
- Industry 4.0 (Big Data, Machine Learning, Artificial Intelligence, and Augmented Reality)
- Engineering and design thinking
- Computational thinking
- 21st Century workforce skills
- Career Connections and exploration of career pathways
**Semester Course with Beginner Level Students (45-75 Hours)**

*One semester course only, students in this sequence would not continue to a second semester.*

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<thead>
<tr>
<th>Unit</th>
<th>Weeks 1-2</th>
<th>Weeks 2-5</th>
<th>Weeks 6-8</th>
<th>Weeks 8-10</th>
<th>Weeks 11-12</th>
<th>Weeks 12-14</th>
<th>Weeks 16-18</th>
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<tr>
<td>FIRST® Challenge and Team Building</td>
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<td>Building and Programming a Basic Robot</td>
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<td>Project Sprints and Competitions</td>
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<td>Learning Pathways and Career Exploration</td>
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**Outcome:**

Students learn the engineering design process, computational thinking, and workforce skills to build a robot to compete. Students are introduced to the robot's systems and the essential math and science needed to build the robot. This scope and sequence would limit the opportunities to dive into the physics and math behind designs and has less of an engineering design approach. It is suggested that students use the REV Edubot guide for build instructions. Students will have a driving robot, a simple manipulator with a basic autonomous and a driver-controlled program for tank drive, and a basic arm for manipulating game objects.
**Outcome:**

In this first semester of the yearlong course, students spend time building the basic robot using the REV Chassis Guide. Then, they spend additional time understanding the game and developing a robot plan on how to design manipulators for the game. This approach gives students an introduction to the many different types of manipulators they might add to the robot and some of the basics of the physics required to design and build manipulators. They have a limited time to iterate the design before a competition. The Careers unit occurs at the end of the entire course for students who continue for a whole year. This approach gives students more time to develop mechanisms, design, and iterate.
### Outcome:

In the second semester, students get the opportunity to explore Industry 4.0 and then determine how it could affect their future. This exploration becomes part of a second-semester community impact project. They apply these skills to the robot, learning how to create programs with sensors, closed-loop feedback, machine learning, and Java. Students can then use these skills and their skills from the Machines to Mechanisms module as they go through the iteration and redesign process for the rest of the semester. Students apply knowledge learned as they troubleshoot and improve their robot designs, learning to overcome failures and refine a mechanical design that uses software automation.
**1st Semester Course with Advanced Level Students (50-85 Hours)**

*Students in this course would have some design and engineering skills. It is the first semester of a full-year course.*

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**Outcome:**

In the advanced scope and sequence, students start with workforce skills. Then, they go straight into designing for the game. In this sequence, students focus on designing for the problem of the game. This sequence requires students have some mechanical knowledge for building and designing. Students go more in-depth into the engineering of mechanisms to achieve a game strategy using physics simulations. They can work on prototyping and designing mechanisms before implementing them into a robot design. They then can take this knowledge and apply it to the *Building and Programming a Basic Robot* module for testing.
 Outcome:
In the second semester, students get the opportunity to explore Industry 4.0 and then determine how it could affect their future. This module becomes part of a second-semester impact project. They then apply these skills to the robot, learning how to create programs with sensors, closed-loop feedback, machine learning, and Java. Students can use these skills and the physics simulations to develop advanced modeling of skills from Machines to Mechanisms as they go through the iteration and redesign process for the rest of the semester. Students apply knowledge as they troubleshoot and improve their robot designs, learning to overcome failures and refine a mechanical design that uses software automation.
## Guiding Question: How can you learn and develop workforce skills through FIRST® to improve your employability for the future?

### Project for Unit: Student Career Card

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| **Core Values** | • Explore FIRST Core Values and their relationship to the workforce.  
• Understand the importance of Gracious Professionalism® and Coopetition®.  
• Develop a team identity and use it for communicating expectations as a team using FIRST Core Values and Gracious Professionalism.  
• Utilize Engineering Notebook Templates to improve written communication as a team while practicing discovery and innovation. |
| **Problem:** How can you use FIRST® philosophies to create a team purpose and achieve it through clear communications and expectations? |

| **Robots and the Workforce** | • Discover what is a robot and how are they used in industry?  
• Discover the parts of a FIRST® Tech Challenge robot and how its technology is transferrable to the workforce.  
• Decompose a robot into how it can plan, sense, and act and the relationship of its systems and distinctions that allow it to achieve a task.  
• Develop design criteria for your robot using the Engineering Design Process. |
| **Problem:** What elements should be in design goals for a FIRST® Tech Challenge robot? |

| **Tools for Problem Solving** | • Discover the Engineering Design Process and tools for computational thinking.  
• Understand how computational thinking tools can help you improve the Engineering Design Process.  
• Use engineering design and computational thinking to solve a design problem.  
• Use computational thinking in the testing process to improve iterations in the design cycle. |
| **Problem:** How do we use the engineering design process and computational thinking to increase critical thinking, problem-solving, and team communication? |
### DATA DETERMINATION℠ Challenge

**Problem:** How do we use computational thinking to understand the game we will compete in with our robot?

- Discover patterns in the game design by looking at the game flow and scoring patterns.
- Gain a deeper understanding of the engineering tasks by taking measurements of the game field and game elements.
- Develop a game strategy and robot algorithms for autonomous, teleop, and end-game.

### Robot Plan

**Problem:** How do you design a robot using your game strategy?

- Brainstorm ideas to achieve the robot actions determined in your game strategy.
- Research the ideas to understand processes others have used to achieve similar strategies.
- Use the physics lab to test out ideas to achieve the game strategy.
- Develop prototypes from the ideas.
- Test prototypes to gain an understanding of system development that will be needed to achieve the game strategy.

### Building and Programming a Basic Robot: Unit Outline (15 hours)

**Guiding Question:** How do you learn technical career skills to build a robot that can complete a timed challenge in driving and moving an object?

**Project for Unit:** Timed Robot Challenge

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</table>
### Building and Programming a Basic Robot: Unit Outline (15 hours)

#### Achieving Goals through Project Management

**Problem:** How can you establish impactful goals and expectations for your team and execute these goals using project management?

- Explore how to make what you learn more impactful.
- Turn expectations into the goals you would like to accomplish.
- Understand the tools available for project management.
- Determine the tools and method your team will use to manage a project.
- Develop a safety plan for your team.

#### Chassis and Drive System

**Problem:** How can we design and build a chassis that considers the center of gravity, speed, torque, and is rigid enough to hold the robot sub-systems?

- Discover different types of chassis configurations and how they achieve different functions.
- Discover principles of speed, torque, the center of gravity, and structural integrity.
- Experiment with principles of chassis speed, torque, and center of gravity using the robot physics lab.
- Use understanding the problem, brainstorming, and decision-making to determine a chassis design.
- Build a robot chassis that best meets your design criteria.

#### Electrical Wiring and Wireless Configuration

**Problem:** What technical skills will you develop while developing communication pathways on the robot?

- Explore basic electrical theory and its importance in wiring the robot.
- Decompose the robot hardware and its importance in robot communication.
- Wire a robot using a wiring diagram and preventative measures to limit electrostatic discharge on the robot.
- Establish wireless communication pathways between the robot and the robot controller.
- Configure the hardware according to the electrical diagram using consistent naming conventions.
- Use a given template in the IDE to test configuration and wiring.

#### Programming

**Problem:** How do you use the FIRST Tech Challenge IDE and computational thinking to write the plans for the robot to act?

- Apply computational thinking to plan algorithms using pseudocode and flow charts.
- Develop algorithms to control motors, servos, and sensors with iteration, open and closed-loop programming methods.
- Learn where abstraction occurs in the programming tools and how it can help you troubleshoot and understand problems.
- Use programming templates to program your robot in Driver Controlled Mode.
- Develop a basic algorithm for autonomous programming drive and park.
# Building and Programming a Basic Robot: Unit Outline (15 hours)

## Manipulators

How do you add manipulators and sensors to expand your robot's ability to plan, sense, and act?

- Explore what a manipulator is.
- Understand how to choose an actuator.
- Choose an actuator to complete a task.
- Use a gear ratio to affect torque and speed to achieve a task.
- Utilize Engineering Notebook Templates to improve written communication as a team.

# Machines to Mechanisms: Unit Outline (10 hours)

**Guiding Question:** How can you choose different simple machines to increase the functionality of your robot to achieve your game strategy?

**Project for Unit:** Timed Robot Challenge

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<tr>
<td><strong>Simple to Complex Machines</strong></td>
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| **Problem:** How can we analyze the forces involved and know the essential calculations of the manipulator to achieve the desired output? | - Explore simple and compound machines and how they are used in robot manipulators.  
  - Understand how forces are involved in machines and proper transfer of forces increases efficiency.  
  - Consider the scalar and vector forces that affect how manipulators accomplish work.  
  - Design a manipulator and analyze the forces involved. Include essential calculations of the manipulator to achieve the desired output. |
## Machines to Mechanisms: Unit Outline (10 hours)

### Levers, Cams, and Linkages

**Problem:** How can you increase the work your manipulators accomplish with levers, cams, linkages, and linear motion?

- Explore ways you can transform motion and develop mechanisms with linkages and cams,
- Understand linkages and degrees of freedom and geometry of designing a mechanism.
- Discover linkages from history and how they are used to transform motion.
- Analyze your team game strategy and robot and determine if linkages and cams can increase your robot’s efficiency.
- Prototype linkages and cams that could help you achieve your game strategy.

### Conveyors, Intakes, and Object Trajectory

**Problem:** How can you design with more automation using the speed of motors to achieve intake, conveyance, or trajectory?

- Explore how machines and mechanisms in industries gather objects and understand essential design principles to an intake mechanism.
- Discover design principles needed for intake or shooting systems.
- Explore ways to use the REV parts to develop intakes and shooters.
- Explore ways to expand your kit of parts with 3D printing and other supplies you might have available.
- Experiment with trajectory, speed, and velocity to propel objects.

## Improving Through Iteration I: Unit Outline (5-15 hours)

**Guiding Question:** How do you improve your robot with data, testing, and innovation?

**Project for Unit:** Timed Robot Challenge

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### Iteration and the Product Life Cycle

**Problem:** How do you improve your robot using the Robot Technical Design Rubric while improving reliability and functionality to meet your design goals?

- Improve your robot by making it simpler by analyzing the design for feasibility, optimality, and reliability.
- Manage the product lifecycle to ensure growth continues through analyzing design weaknesses. Create a project management plan for improving those weaknesses.
- (Optional) Use CAD to track versions and design changes on your robot.

### Mechanism Improvement

**Problem:** How can you improve the mechanisms on your robot by using industry machines for inspiration?

- Brainstorm ways of improving your mechanisms using industry machines as inspiration for a design.
- Prototype ideas for improving your mechanisms and use a decision matrix to determine the most effective one.

### Algorithm Improvement

**Problem:** How do you improve the algorithms on your robot as you add functionality and hardware to it?

- Use computational thinking to identify additional algorithms needed to control your robot or its actuators. Record information for understanding the problem in your Engineering Notebook.
- Use components of flow control to increase functionality such as additional conditional logic, variables, or operators. Record code modifications and testing in the Engineering Notebook.

### Project Sprints and Competition: Unit Outline (5-15 hours)
**Guiding Question:** How do you improve project management and communication skills while preparing for a competition?

**Project for Unit:** Robot Competition and Presentation

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<tr>
<td><strong>Conducting a Project Management Sprint</strong></td>
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</table>
| **Problem:** How can you complete a project management sprint to address problems on the robot and prepare for the competition? | • Complete a project sprint for tasks to be completed on the robot.  
• Complete a project sprint for your Engineering Notebook.  
• Complete an evaluation of our project management sprint to determine any roadblocks. |
| **Presentation and Competition** |  |
| **Problem:** How do you improve your communication skills by presenting and demonstrating your knowledge to others? | • Create a team summary of your successes.  
• Develop a team presentation to articulate your team’s purpose, goals, and accomplishments.  
• Compete with your team in a Mini-Game Competition. |
| **Learning Portfolio** |  |
| **Problem:** How can you develop a portfolio that shows your skills to help you pursue your future goals and career? | • Identify your strengths and weaknesses using the course rubrics.  
• Provide evidence of your strengths with references to the Engineering Notebook.  
• Make improvements to your portfolio based upon feedback from your team. |
**Industry 4.0 and Your Community: Unit Outline (5-15 hours)**

**Guiding Question:** How can you understand your community and the potential skills you will need to develop for a career in an industry 4.0 workforce and its impact on your community and society?

**Project for Unit:** Community Impact Project

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<tr>
<td><strong>Industry 4.0 and Your Robot</strong></td>
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<tr>
<td><strong>Problem:</strong> How can building your robot increase your knowledge for an Industry 4.0 Career?</td>
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<td>• Develop a presentation on your robot's utilization of Internet of Things technology.</td>
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<td>• Brainstorm ways the robot can use big data, augmented reality, and machine learning to better its automation and efficiency.</td>
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<td>• (Optional) Use industry tools such as augmented reality from PTC or collaboration tools.</td>
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<tr>
<td><strong>Industry 4.0 and Your Community</strong></td>
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<tr>
<td><strong>Problem:</strong> How can you utilize Industry 4.0 in your community to impact others' understanding of STEM?</td>
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<td>• Create a Venn diagram poster that could be used to educate others about Industry 4.0 and the future.</td>
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<td>• Develop a plan to impact your community through a project, awareness, or education of Industry 4.0 and the future.</td>
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<td><strong>Share with Your Community</strong></td>
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<td><strong>Problem:</strong> How can you share the impact with others through an event to benefit you and your community?</td>
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<td>• Brainstorm ways to implement a community event where you can share the knowledge you have learned.</td>
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<td>• Work with the rest of your class to determine how each team will help to contribute to the planning and even implementation of the event.</td>
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**Sensors, Machine Learning, and Java: Unit Outline (5-15 hours)**

**Guiding Question:** How can we use the robot to learn data analytics skills, including error reduction, functions, feedback, state machines, and image processing, to develop skills to help us in an Industry 4.0 future??

**Project for Unit:** Time Robot Test

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| **Problem:** How can you increase feedback and control using sensors and improve program flow with Boolean data? | - Use a decision matrix to evaluate and choose sensors to improve robot feedback and performance.  
- Use a truth table and flow chart to evaluate the logic and program flow of your robot.  
- Choose one sensor to implement on your robot and use computational thinking to further develop your algorithm to reduce cumulative error. |
| **Developing Functions and States** | |
| **Problem:** How can you increase abstraction and robot control through functions and states? | - Use functions in your autonomous program to improve your autonomous program.  
- Improve your code using encoders for navigation, and if possible, use the IMU for turning navigation.  
- Use computational thinking to analyze your code for state machine development for your autonomous program. |
Sensors, Machine Learning, and Java: Unit Outline (5-15 hours)

Developing Robot Machine Learning

**Problem:** How can you utilize your robot's ability to perform machine learning through vision processing?

- Develop a data table of how your robot might make decisions and classify objects.
- Explore the tools available for using image processing via the Webcam. Utilize GitHub to test the webcam and its capability for April tag Recognition.

Object-Oriented Programming

**Problem:** How is an abstraction used in Java to handle communicating with different components in a program?

- Decompose your Java program understanding syntax, methods, objects, and classes.
- Use myBlocks to convert functions that you have created into myBlocks.
- (Optional) Use an external source to learn more in-depth Java programming.

Improving Through Iteration II: Unit Outline (5-15 hours)

**Guiding Question:** How do you improve your robot with data, testing, and innovation??

**Project for Unit:** Timed Robot Challenge

| Lesson | Student Outcomes |
## Improving Through Iteration II: Unit Outline (5-15 hours)

### Mechanism Improvement

**Problem:** How can you improve the mechanisms on your robot by improving the design idea and its execution?

- Use project management to improve your robot’s reliability and functionality.
- Brainstorm and analyze using the physics lab ways to improve a design with more speed and efficiency.
- Use CAD or 3D printing to improve your innovation and functionality on the robot while developing career skills.

### Algorithm Improvement

**Problem:** How do you improve the algorithms on your robot as you add functionality and hardware to it?

- Coordinate your hardware and software by adding more hardware to your configuration file and identifying the data needed for the hardware.
- Identify possible algorithms for using the hardware and record testing data.
- Increase flow control through decreasing cumulative error and improving data processing.

### Project Management Sprint II

**Problem:** How can you complete a project management sprint to address problems on the robot and prepare for the competition?

- Complete a project sprint for tasks to be completed on the robot.
- Complete a project sprint for your Engineering Notebook.
- Complete an evaluation of your project management sprint to determine any roadblocks.
# Learning Pathways and Career Development: Unit Outline (5-15 hours)

**Guiding Question:** How can you apply the skills you have learned in possible careers and seek additional opportunities for your future?

**Project for Unit:** Engineering Portfolio, Resume and Learning Plan

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| **Learning Pathways and Competition Teams** | • Explore team roles on a FIRST® competitive team and their correlation to jobs in different industries. Learn the benefits of being on a competitive team that can advance regionally and internationally.  
• Identify how career pathways on a competitive team can help you achieve scholarships, internships, and industry credentials. Create three goals for your future career path.  
• Explore careers and internship opportunities from FIRST Strategic Partners.                                                                                               |
| **Problem:** How can you continue to learn about robotics on a competitive team and get access to scholarships and industry certifications? |                                                                                                                                                                                                                 |
| **Resume**                                  | • Understand the principles of writing a good résumé and the difference between an entry-level résumé and a professional résumé. Use this to build a résumé that demonstrates the impact you make with your workforce and technical skills.  
• Gain feedback and improve your résumé for potential scholarships, employers, or community members.  
• Apply for digital badges and take advantage of networking opportunities in Tallo.                                                                                   |
| **Problem:** How can you develop a résumé to share with potential scholarship providers, employers, or community members? |                                                                                                                                                                                                                 |
| **Learning Portfolio**                      | • Identify your strengths and weaknesses using the course rubrics.  
• Provide evidence of your strengths with references to the Engineering Notebook.  
• Make improvements to your portfolio based upon feedback from your team.                                                                                               |
| **Problem:** How can you develop a portfolio that shows your skills |                                                                                                                                                                                                                 |
Learning Pathways and Career Development: Unit Outline (5-15 hours)

to help you pursue your future goals and career?