FIRST® Tech Challenge
Class Pack Curriculum
Scope and Sequence Options

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.

Unit	Weeks 1-2	Weeks 2-5	Weeks 6-8	Weeks 8-10	Weeks 11-12	Weeks 12-14	Weeks 16-18	Hours
Starting with Workforce Skills								10
Building and Programming a Basic Robot								15
Designing for the Game								5-15
Improving through Iterations I								5-15
Project Sprints and Competitions								5-10
Learning Pathways and Career Exploration								5-10

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.

1st Semester Course with Beginner Level Students (40-70 Hours)

Students in this course would continue for a full year of a beginning level engineering or robotics course.

Unit	Weeks 1-2	Weeks 2-5	Weeks 6-8	Weeks 8-10	Weeks 11-12	Weeks 12-14	Weeks 16-18	Hours
Starting with Workforce Skills								10
Building and Programming a Basic Robot								10
Designing for the Game								5
Machines and Mechanisms								5
Improving through Iterations I								5-30
Learning Pathways and Career Exploration								5-10

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.

2nd Semester Course with Beginner Level Students (65-75)

This is the 2nd Semester of a full year Intro to Engineering with Beginner Level Students

Unit	Weeks 1-2	Weeks 2-5	Weeks 6-8	Weeks 8-10	Weeks 11-12	Weeks 12-14	Weeks 16-18	Hours
Industry 4.0								10
Sensors, Machine Learning and Java								15
Improving through Iterations II								10
Project Sprints and Competitions								5
Improving through Iterations II								10-15
Project Sprints and Competitions								5
Learning Pathways and Career Exploration								15

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.

Unit	Weeks 1-2	Weeks 2-5	Weeks 6-8	Weeks 8-10	Weeks 11-12	Weeks 12-14	Weeks 16-18	Hours
Starting with Workforce Skills								10
Designing for the Game								10
Machines and Mechanisms								15
Building and Programming a Basic Robot								10
Improving through Iterations I								5-30
Project Sprints and Competitions								5-10

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.

2nd Semester Course with Advanced Level Students (50-85)

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

Unit	Weeks 1-2	Weeks 2-5	Weeks 6-8	Weeks 8-10	Weeks 11-12	Weeks 12-14	Weeks 16-18	Hours
Industry 4.0								10
Sensors, Machine Learning and Java								10
Improving through Iterations II								10-20
Project Sprints and Competitions								5
Improving through Iterations II								5-20
Learning Pathways and Career Exploration								10-20

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.

Starting with Workforce Skills: Module Outline (10 Hours)

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

Lesson	Student Outcomes
Core Values **Problem:** How can you use *FIRST*® philosophies to create a team purpose and achieve it through clear communications and expectations?	• Explore *FIRST* Core Values and their relationship to the workforce. • Understand the importance of *Gracious Professionalism*® and *Coopertition*®. • 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.
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.
Tools for Problem Solving **Problem:** How do we use the engineering design process and computational thinking to increase critical thinking, problem-solving, and team communication?	• 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.

Starting with Workforce Skills: Module Outline (10 Hours)

Career Card

Problem: How can you learn and develop workforce skills through *FIRST*® to improve your employability for the future?

- Use the Career skills rubric to identify strengths and weaknesses.
- Develop a personal purpose, focus, how you will achieve the focus, and skills you add to the team.
- Create a career card that demonstrates who you are.
- Develop a team summary that encompasses team members' talents and skills and the purpose you hope to achieve as a team

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

Lesson	Student Outcomes
Robots and the Workforce **Problem:** What elements should be in design goals for a *FIRST*® Tech Challenge robot?	• 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.

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

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.
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.

Designing for the Game: Unit Outline (5-15 hours)

Guiding Question: How do I develop a design plan for a robot to compete in a game that has complex strategies and mechanical considerations needed?

Project for Unit: Robot Plan

Lesson	Student Outcomes
Game Plan **Problem:** How do we use computational thinking to understand the game we will compete in with our robots?	• Explore the components of a FIRST Tech Challenge Game. • Understand where to find details that are abstracted in the Game Rules. • Explore details of the game using measurements and algorithms. • Brainstorm ideas for competing in the game. • Use a decision matrix to determine a game plan.
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.

Designing for the Game: Unit Outline (5-15 hours)

Robot Challenge by Unit	• Students can use beginner, intermediate or advanced robot achievement goals to increase skill level with each unit. • The tasks are identified by unit and can be referred tAo throughout the course after the Game release.

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

Lesson	Student Outcomes
Simple to Complex Machines **Problem:** How can we develop manipulators with simple machines to accomplish tasks in a game?	• 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 manipulator accomplishes with linkages and cams?	• 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.
Linear Pulley Systems and Mechanical Advantage **Problem:** How can you improve linear movement on your robot?	• Know how to calculate mechanical advantage for a pulley system. • Apply your knowledge of calculating speed to a pulley system. • Gain a better understanding of how to design linear slides and pulley systems. • Explore rack and pinion and worm gear linear slides

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

Lesson	Student Outcomes
Iteration and the Product Life Cycle **Problem:** How do you improve your robot through the Engineering design process and iteration?	• Explore problem-solving strategies such as improving reliability, functionality, craftsmanship. • Explore how increasing the functionality and optimality of a design can increase reliability. • Use design criteria to evaluate project needs and priorities for improvement. • Understand the productive struggle and the product life cycle and its effect on the design and iteration process.
Mechanism Improvement **Problem:** How can you improve the mechanisms on your robot by using industry machines for inspiration?	• Explore machines that operate with reliability and precision. • Research ways that other mechanisms in the industry complete similar tasks. • Identify the shortest path for the object to be transported from point A to point B. • Prototype and improve your mechanism design.

Algorithm Improvement **Problem:** How do you improve your robot's algorithms as you add additional functionality and hardware to the robot?	• Explore the steps to add additional hardware and data needed for the hardware. • Identify the data needed for additional hardware and how the data will need to be processed to achieve additional functionality. • Use the engineering design process to understand the details of algorithms to add functionality to the robot.

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

Lesson	Student Outcomes
Conducting a Project Management Sprint **Problem:** How can you complete a project management sprint to address the robot's problems and prepare for the competition?	• Understand and apply the process of a project management sprint. • Use a time crunch with deadlines to tackle many tasks quickly. • Identify priorities for completion. • Monitor and ensure that we make progress. • Use workforce skills to prepare for our competition day.

Communication and Presentation **Problem:** How do you improve your communication skills by presenting and demonstrating your knowledge to others?	• Understand how to identify your strengths and weaknesses. • Explore ways to communicate about strengths and weaknesses. • Develop and present your team to an audience.
Engineering Portfolio **Problem:** How can you develop a portfolio that shows the skills you have learned to help you pursue your future goals and career?	• Identify and communicate about your career and technical skills. • Develop a portfolio that demonstrates the skills you have acquired in the course.

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

Lesson	Student Outcomes

Industry 4.0 and Your Community: Unit Outline (5-15 hours)

Industry 4.0 and Your Robot **Problem:** How can building your robot increase your knowledge for an Industry 4.0 Career?	• Understand what Industry 4.0 technology is and where I can find it in my daily life. • Discover what big data is and how it influences the ability to increase innovation. • Discover what is the Internet of Things and how it could change your future career? • Understand what Artificial Intelligence and machine learning are and how it applies to your robot. • Consider how you could use augmented reality to improve your education and collaboration on your robot.
Industry 4.0 and Your Community **Problem:** How can you utilize Industry 4.0 in your community to make an impact on others' understanding of STEM?	• Explore ethical concerns around Industry 4.0. • Explore ways you can make an impact on others. • Develop a plan to make an impact in your community through a project, awareness, or education of Industry 4.0 and the future.
Share with Your Community **Problem:** How can you share your impact project with others to benefit you and your community?	• Explore audiences and ways to share the impact you wish to make. • Brainstorm the best method to share your learning in your community. • Develop a project management plan for sharing your learning.

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??

Sensors, Machine Learning, and Java: Unit Outline (5-15 hours)

Project for Unit: Time Robot Test

Lesson	Student Outcomes
Sensors and Feedback **Problem:** How can you increase feedback and control with sensors, state machines, and improved program flow?	• Understand touch, color, and encoder capabilities for providing feedback to the robot. • Decompose sensor data to determine how it collects and receives data. • Develop algorithmic thinking through utilizing Boolean data, program flow, and decisions to improve the robot. • Utilize decision trees to understand program flow and decisions that are made by the robot. • Develop a robot program that includes increased program flow with compound Boolean data, operators, and functions.
Developing Functions and States **Problem:** How can you use abstraction and algorithmic thinking to improve program flow?	• Explore the machine states and how they provide feedback for robot control. • Explore ways of creating abstraction in code through functions. • Use the robot Inertial Measurement Unit to improve robot navigation through functions, • Consider autonomous states of your robot, then use abstraction to create functions using states for an autonomous program.
Developing Robot Machine Learning **Problem:** How can you utilize your robot's ability to perform machine learning through vision processing?	• Explore decision trees and how they help a robot make decisions. • Understand what machine learning and the process used to develop machine learning modules. • Discover the prebuilt machine learning models using TensorFlow and Vuforia. • Decompose a machine learning template and use it to perform robot actions. • (Optional) Create a machine learning model for a custom game piece.

Sensors, Machine Learning, and Java: Unit Outline (5-15 hours)

Object-Oriented Programming

Problem: How is abstraction used in Java to handle communicating with different components in a program, and how do I transition to learn how to program in Java?

- Explore how to enable Java to compare your Blocks programs to Java Programs.
- Explore the syntax of Java programming.
- Discover Java as an object-oriented programming environment.
- Discover the Java code repository to explore inheritance, classes, methods, and objects.
- Use tutorials to develop Java programs for Creating an OpMode, Programming a Motor, and a Sensor.

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
Mechanism Improvement **Problem:** How can you improve the mechanisms on your robot by using industry machines for inspiration?	• Explore the path the game object is taking. • Study the physics behind the design. • Research additional manufacturer ways of improving the use of materials. • Consider better fabrication of the design. • Prototype and improve your mechanism design.

Iteration II: Unit Outline (5-15 hours)

Algorithm Improvement **Problem:** How do you improve your robot's algorithms as you add additional functionality and hardware to the robot?	• Explore the steps to add additional hardware and data needed for the hardware. • Identify the data needed for additional hardware and how the data will need to be processed to achieve additional functionality. • Use the engineering design process to understand the details of what will be needed from an algorithm standpoint to add functionality to the robot
Conducting a Project Management Sprint **Problem:** How can you complete a project management spring to address the robot's problems and prepare for the competition?	• Understand and apply the process of a project management sprint. • Use a time crunch with deadlines to tackle many tasks quickly. • Identify priorities for completion. • Monitor and ensure that we make progress. • Use workforce skills to prepare for our competition day.

Learning Pathways and Careers: 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

Lesson	Student Outcomes

Learning Pathways and Careers: Unit Outline (5-15 hours)

Engineering Portfolio **Problem:** How can you develop a portfolio that shows the skills you have learned to help you pursue your future goals and career?	• Identify and communicate about your career and technical skills. • Develop a portfolio that demonstrates the skills you have acquired in the course.
Resume and Digital Badge **Problem:** How you develop a resume to communicate your skills for future jobs and opportunities?	• Learn the principles of developing a good resume. • Use your portfolio to articulate your skills on a resume. • Learn about digital badges and sharing your skills and resume with others. • Develop a resume and apply for a digital badge.
Learning Pathways and Competition Teams **Problem:** How can I continue my learning on a competition team and pursue industry certifications?	• Explore team roles and responsibilities on competition teams. • Learn about the Industry Certification pathways associated with those roles. • Explore opportunities in my area to continue with *FIRST*. • Develop learning goals and a learning plan.