Introduction to Engineering Course Outline

Prerequisite – None

Equipment requirements – FIRST Tech Challenge Edubot or FIRST Tech Challenge Competition Set

Incorporate hands-on learning, career exploration, and workforce and industry-ready skills into your classroom or after-school curriculum using the FIRST Tech Challenge Class Pack curriculum and resources. In this yearlong course, students are given online access to curriculum, learning videos, and physics simulations. They spend time building the basic robot using a build guide and a mini-game competition provided with the curriculum. 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.

Unit	Learning Objectives	Time
Starting with Workforce Skills	*Core Values* • 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* • 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* • 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. *Career Card* • 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.	10 hours
Building and Programming a Basic Robot	*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.	25 hours

	• 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. *Chassis and Drive System* • 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* • 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* • 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* • 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	*Game Plan* • 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* • Brainstorm ideas to achieve the robot actions determined in your game strategy.	15 hours

	• 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. *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 to throughout the course after the Game release.	
Machines to Mechanisms	*Simple to Complex Machines* • 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. *Levers, Cams, and Linkages* • 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* • 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* • 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.	15 hours
Improving through Iterations I	*Iteration and the Product Life Cycle* • Explore problem-solving strategies such as improving reliability, functionality, craftsmanship. • Explore how increasing the functionality and optimality of a design can increase reliability.	15 hours

	• 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* • 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* • 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	*Conducting a Project Management Sprint* • 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* • 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* • Identify and communicate about your career and technical skills. • Develop a portfolio that demonstrates the skills you have acquired in the course.	15 hours
Industry 4.0 and Your Community	*Industry 4.0 and Your Robot* • 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* • 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* • 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.	15 hours

Sensors, Machine Learning, and Java	*Sensors and Feedback* • 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* • 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* • 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. • Create a machine learning model for a custom game piece. *Object-Oriented Programming* • 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.	15 hours
Improving through Iterations II	*Mechanism Improvement* • 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. *Algorithm Improvement* • 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* • Understand and apply the process of a project management sprint.	15 hours

	• 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	*Engineering Portfolio* • 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* • 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* • 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.	15 hours