UNIT 0

Preparing for School

UNIT OVERVIEW

UNIT NUMBER: 0 **DURATION: 5-10 hours**

SUMMARY

This unit is to help the teacher prepare for the school year by becoming familiar with the curriculum, equipment, and requirements of running a *FIRST*® Tech Challenge team in the classroom.
https://youtu.be/A_e5r1lXraY

INSTRUCTIONS

1. Design your physical classroom.
2. Gather and organize your tools.
3. Understand how to manage a FIRST Tech Challenge classroom.
4. Understand the grading system.

Gain technical experience.

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

CLASSROOM REQUIREMENTS

Spatial Layout

Students need a lot of room to work. A standard row/column desk classroom will not be ideal. Large work tables for kids to gather around materials and collaborate is preferred. They will also need a significant amount of floor space to test the robot and setup portions of the field for testing.

Number of students per group/team

You will need to decide how many ***FIRST***® Tech Challenge teams to have in your classroom. A ***FIRST*** Tech Challenge team may have up to 15 people. But keep in mind that typically no more than three people can be hands on with a robot at a time and still be productive. Keeping teams smaller than 10 is preferred for classroom implementation. When the robot is occupied, other members should be working on programming, CAD (computer-aided design), planning, or organization.

Budgeting and Materials

This page of the ***FIRST***® website discusses the general cost of participating in ***FIRST*** Tech Challenge. The only *required* costs for new teams are Team Registration, Kit of Parts, and Tools.

FIRST has received generous donations to help us get more young people involved in our life-changing programs.

Grants are available for Rookie and Veteran ***FIRST*** Tech Challenge Teams. Register for this season and apply for a grant! Learn more here.

More information about need-based and other grants can be found on this page.

REGISTRATION, ORDERING KITS, AND TOURNAMENTS

Registering Teams

It is intended that students in this course will take part in at least one official *FIRST* Tech Challenge competition event. However, it is not required. If a team chooses not to compete at an official event, an in class event can be a fun alternative. Each class will need to register teams to receive the kit of parts.

Follow the steps below to create a ***FIRST*** account and register your teams.

1. Create an account with ***FIRST*** here.

2. Then register your team(s).
   https://youtu.be/1AIRgD4XBGk
3. Each team must also have two registered coaches. Watch the video below and then add a second coach to your team(s).
   https://youtu.be/l3gKOm501FM

Ordering Kits

1. Now you will need to order a Kit of Parts and pay for each of your teams.
   https://youtu.be/OoUvwScLyT8

Background Checks with Youth Protection Program

FIRST*'s** Youth Protection Program requires all ***FIRST teams to have two screened Lead Coaches/Mentors for the entire season and all volunteers screened for official events. This means that as a coach, you and any other adults working with the team (at least one) will need to be screened. Background screening is integrated into the Team Registration System. The Youth Protection Program page of the ***FIRST*** website contains additional guidance on the screening process.

https://youtu.be/Llm2mMV8WHs

Kickoff and Tournaments

FIRST® Tech Challenge season kickoff is in September! Many regions host kickoff events to get ready for the new season.
Local tournaments begin in November. You will need to register to compete in a local tournament with your region's partner. Use this page to find kickoff events and tournaments near you.
Reach out to your local Affiliate Partner in order to sign up for a tournament. Find your Affiliate partner here.

GATHERING TOOLS

Gathering Tools

Rookie teams often don't need many tools in order to build a working robot, but more advanced teams often use power tools to build more complex designs. The tools in the list of "Essential Tools" below will be required for all teams, while the "Helpful Tools" may only be useful for advanced teams.

If you are working in a shop type space at your school, these tools may already be available and being used by other programs. Check to see what your school has on hand before purchasing. You

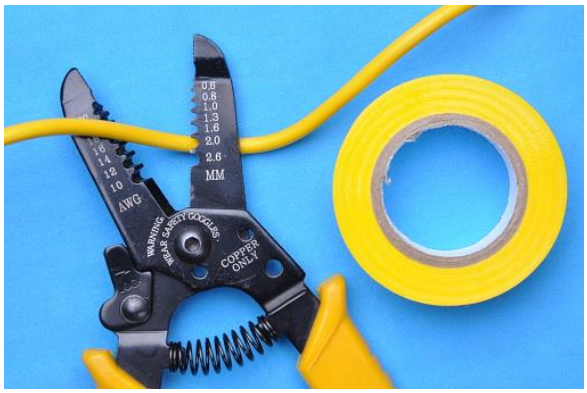
may be able to acquire many of the tools through donations of used tools or from local hardware stores.

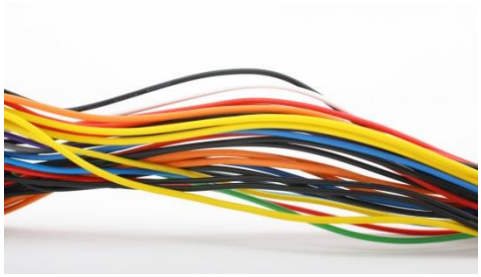
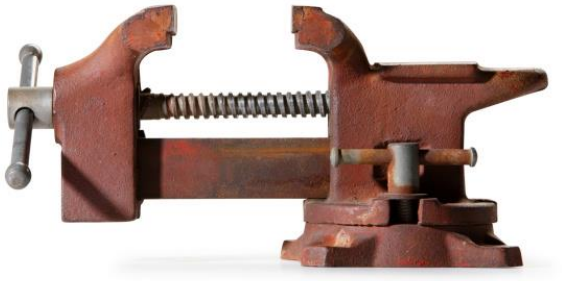
Essential Tools

• Allen wrench set (comes with the Kit of Parts)	
• Small Phillips head screw driver	
• ANSI Z87.1 certified safety glasses for every student - mount them in a prominent location near the entrance to the class to encourage students to get them as they come in	

Helpful Tools

• Wire cutters	

	
• Wire strippers	
• Powerpole Crimping tool	
• Powerpoles	

• Extra power wires	
• Hack saw	
• Drill	
• Vice	

• Vice grips	
• File (for smoothing metal edges)	

Storing Tools
Designate a place to store and lock the tools to keep them safe and to keep people from using them at unauthorized times or without supervision. A closet or locked room is preferable.

MANAGING THE CLASS

Understand Your Role

The main role you will play as the teacher is facilitator. You will walk around from group to group throughout the class checking on their progress, pointing them to scaffolding resources when necessary, and making sure they stick to their timeline. You will rarely, if ever, be standing in front of the class imparting information upon students.

Be sure to establish norms that support students in framing the class as a privilege, and their work as their responsibility.

Project-Based Learning

This curriculum is designed in a project-based manner. If you are unfamiliar with project-based learning (PBL), managing a PBL course is very different from managing a traditional teacher-driven classroom. Here are a few resources to help you get up to speed on running a PBL class.

- What is project-based learning?
- Why should we use project-based learning?
- How do I run a project-based class? - See the attached document entitled "BIE Project-Based Teaching Practices."

A big part of project-based learning and the ***FIRST***® experience is failure. Students will not have all the answers at the beginning, and neither will you. Learning comes through trying, failing, iterating, and trying again. That's okay! The traditional classroom does not make room for failure, but in this class you must. You cannot get discouraged when your students mess up, and you cannot prevent them from doing so (unless there is physical danger, of course). To do so would be to rob them of valuable learning opportunities. See the following articles about the importance of failure:

1. Inspired by: Thomas A. Edison
2. Making Friends with Failure

Goal Setting

Set aside time at the beginning of the week to have students designate their priorities for the week. Have every student do it at the same time to make sure they complete it. The next time they set goals, have them check to make sure they achieved their previous goals.

The document attached to this page entitled "Project Team Work Plan" can help teams write out tasks, and assign responsible parties and due dates.

Class Period Duration

Robotics takes time. The longer your class period, the better. Many teams may need to supplement their class time with after school work sessions. Ensuring that students have a clear work plan for the week helps maximize the use of class time.

Budget at least 5 minutes at the beginning and end of each class period to setup and clean up the work space.

ASSESSMENTS

This material in this class includes a lot of technical skills, but the class as a whole focuses heavily on design thinking, problem solving, critical thinking, and collaboration. Some students will learn more about programming than others, while some will learn more about mechanical engineering. That's okay. But every student will learn to think, design, solve problems, and work in a team. The assessments in this class have been designed likewise.

The assessments for this class are designed to focus on the process of learning, rather than the product. We want students to think about their process and be able to articulate it and refine it. We want them to be able to recognize both their successes and their failures and analyze why they happened. We want to give them the freedom to make mistakes and the tools they need to learn from them.

Assessments in this class will include:

1. Weekly Engineering Notebook entries
2. Weekly Self & Peer Evaluations
3. Design Presentations
4. Occasional Quizzes

GAIN EXPERIENCE

The students will be doing the work and driving their own learning and you will be learning along with them but it never hurts for you to have some prior knowledge or experience! Try things out yourself ahead of time. It might be useful (but not required) for you to be familiar with the Kit of Parts and programming so that you can help clarify concepts and facilitate student learning. It is recommended to view the tutorials in the Introduction to Robotics unit ahead of time.

Programming

The following tutorials can help you become familiar with Java programming. These can be provided to students as well for those who want to learn more about Java.

- Codecademy
- Learn Java Online

Engineering Notebook Weekly Assessment

The ability to reason, problem-solve, develop sound arguments or decisions, and create new ideas by using appropriate sources and applying the knowledge and skills of a discipline

INITIATING THE INQUIRY

What is the evidence that the student can formulate questions and develop designs related to solving a problem?

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
ASKING QUESTIONS	• Formulates a general question • Provides limited or irrelevant content information		• Formulates a specific question • Provides general content information that is related to the question		• Formulates a specific and testable question related to the problem • Provides specific and relevant content information to support the question		• Formulates a specific, testable, and challenging question related to the problem • Provides specific and relevant content information to provide insight into the inquiry
DEVELOPING AND USING MODELS	• Drawings, diagrams, or models relevant to the problem include major conceptual or factual errors, or are missing • Discussion on limitations or accuracy of model as a representation of the system or process is flawed or missing		• Constructs generally accurate drawings, diagrams, or models to represent the process or system to be investigated • Makes note of limitations or accuracy of model as a representation of the system or process		• Constructs accurate drawings, diagrams, or models to represent the process or system to be tested • Explains limitations and accuracy of model as a representation of the system or process		• Constructs accurate and detailed drawings, diagrams, or models to represent the process or system to be investigated and provides an explanation of the representation • Explains limitations and accuracy of model as a representation of the system or process and discusses how the model might be improved

Adapted by New Tech Network, June 6, 2013

PLANNING AND TESTING PROTOTYPES

What is the evidence that the student can plan and test prototypes to explore design strategies?

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
DESIGNING THE PROTOTYPE	• Design is not aligned to the testable question • Discussion of how the model can guide or inform the design or an aspect of the design is missing		• Design is related but not explicitly aligned to testable question • States in general terms how model was used to guide, inform, or test the design or an aspect of the design		• Aligns design with testable question • Explains how model was used to guide, inform, or test the design, or an aspect of the design		• Explains the alignment between the design and the testable question • Explains how model was used to guide, inform, or test the design, or an aspect of the design
TESTING PROTOTYPES	• Includes vague or incomplete testing procedures; or uses inappropriate tools, instruments, or types of measurement		• Describes testing procedures including tools/ instruments used, but is not clear or detailed enough to be replicated		• Describes detailed, clear, and replicable testing procedures including tools /instruments and types of measurements gathered		• Describes detailed, clear, and replicable testing procedures including rationale for using the tools /instruments and types of measurements gathered
DOCUMENTING TESTS	• Gathers data from a single test of the design • Limitations of the tests are not mentioned		• Documents results from several tests of the design that are not comprehensive of all circumstances • Mentions limitation of the tests		• Documents results from several tests of the design that explore some extraneous or unexpected circumstances • Explains limitations of the tests		• Documents results from several tests of the design that explore extensive extraneous and unexpected circumstances • Explains limitation of tests and impact on future designs

REPRESENTING, ANALYZING, AND INTERPRETING TEST RESULTS *What is the evidence that the student can organize, analyze, and interpret test results?*							
	EMERGING	**E/D**	**DEVELOPING**	**D/P**	**PROFICIENT**	**P/A**	**ADVANCED**
ANALYZING THE RESULTS	• Analyzes data using inappropriate methods or with major errors or omissions • Consistency of outcome with initial expectations, when appropriate, is not compared		• Accurately analyzes data using appropriate methods with minor omissions • Compares consistency of outcome with initial expectations, when appropriate		• Accurately analyzes data using appropriate and systematic methods to identify patterns • Compares consistency of outcome with initial expectations when appropriate and identifies possible sources of error		• Accurately analyzes data using appropriate and systematic methods to identify and explain patterns • Compares and explains consistency of outcome with initial expectations, when appropriate and explains possible sources of error and impact of errors
GENERATING INTREPRETATIONS	• Inferences drawn from results are absent • Makes no mention of design adjustments needing further investigation		• Draws inferences from results without discussing strengths or weaknesses • Makes note of design adjustments that need further investigation		• Explains the strengths OR weaknesses of the inferences drawn from results • Suggests design adjustments worth further investigation		• Explains the strengths AND weaknesses of the inferences drawn from results • Suggests design adjustments worth further investigation and poses new analysis or design

CONSTRUCTING EVIDENCE-BASED ARGUMENTS AND COMMUNICATING CONCLUSIONS

What is the evidence that the student can articulate evidence-based explanations and effectively communicate conclusions?

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
COMMUNICATING RESULTS AND NEXT STEPS	• Attempts to use multiple representations to communicate results with inaccuracies or major inconsistencies • Implies results with no discussion of next steps		• Uses multiple representations (words, tables, diagrams, graphs and/or mathematical expression) to communicate results with minor inconsistencies • States results and general discussion of next steps		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear results • Explains results with specific discussion of next steps		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear and specific results • Explains results and impact on next steps
FOLLOWING CONVENTIONS	• Uses language and tone inappropriate to the purpose and audience • Attempts to follow the norms and conventions of scientific writing with major, consistent errors, for example in the use of technical terms, quantitative data, or visual representations		• Uses language and tone appropriate to the purpose and audience with minor lapses • Follows the norms and conventions of scientific writing with consistent minor errors, for example in the use of technical terms, quantitative data, or visual representations		• Uses language and tone appropriate to the purpose and audience • Follows the norms and conventions of scientific writing, including accurate use of technical terms, quantitative data, and visual representations		• Uses language and tone appropriate to the purpose and audience • Consistently follows the norms and conventions of scientific writing, including accurate use of technical terms, quantitative data, and visual representations

©2013 Stanford Center for Assessment, Learning, and Equity (SCALE) and Envision Schools **Adapted by New Tech Network, June 6, 2013**

What went well in your team’s work?

How could you have improved your team’s performance?

How could others on your team have improved your team’s performance?

Please use this area to write about your own participation in the last competition.

UNIT 1

Safety

UNIT OVERVIEW

UNIT NUMBER: 1 **DURATION: 5 hours**

SUMMARY

Building a robot requires a lot of parts, electronics, and tools. The process can easily become dangerous if not done carefully. In this unit, students will learn about and demonstrate workshop safety, as well as develop rules for conduct and tool use in the workshop.

INSTRUCTIONS

1. Discuss General Workshop Safety with your students.
2. Discuss specific Tool Safety with your students.
3. Give the Safety Quiz.
4. Certify students to use individual tools.

LEARNING RESOURCES

1. Safety Guidelines Handout
2. Hacksaw Safety
3. Power Drill Safety

ASSESSMENTS:

1. Safety Quiz

TOOLS & MATERIALS

1. Jig saw
2. Hack saw
3. Drill
4. Soldering iron
5. Electric Grinder

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

General Workshop Safety

Go through general workshop safety with the students.

1. Present the Safety Guidelines handout to the students.
2. Talk about each rule and why it's important. If there are any rules you and/or the students wish to add, discuss them as a class and append them to the list.
3. Have the students create a poster listing the safety rules and display it in a prominent place in the workshop.
4. Give the students a quiz over the general safety rules.

TOOL SAFETY

1. Count the number of different power tools you have in your workshop. Divide your students into groups, one for each tool.
2. Have each group research the proper use of each tool and create a list of instructions. They may search online, watch training videos from this unit's learning resources, or read safety instructions from the tool's manual.
3. Each group will present their instructions to the class. Discuss with the whole class. If any important details are missing be sure to add them to the list.
4. Keep the instructions so that students may reference them at any time.

DEMONSTRATING TOOL SAFETY

Before any student may use a tool, they must demonstrate proper use of the tool. Use the general safety instructions and individual tool instructions created by the students to assess whether the student is capable of safely operating the tool.

If you have the time, it is beneficial to have every student demonstrate use of every tool. This may take a long time, however, so it's okay to let students specialize in tools at the beginning. But be sure no student uses a tool they have not demonstrated they know how to use. A printable chart is provided to help you keep track of the tools and the students that are cleared to use them.

Safety Guidelines

Building a robot requires many tools and can be dangerous. In order to keep everyone safe, we will follow the rules below at ALL times.

- NO TOOL USE when instructor isn't present!!
- Never use a tool you haven't been trained to use or shown the proper techniques by the instructor; always *ask for help* before using a new tool, or if you're not sure
- **Hand/Eye protection:** Always wear protective glasses when using tools, and work gloves if you're working with sharp edges like metal or plastic
- **Entanglement**: *Always* pull hair back so it doesn't dangle into work area; remove or tie off loose clothing, scarves, sleeves, etc.
- **Electric hazards**: *No water* around power tools - stay away from the sink! Be careful that any electrical cords are well out of the way of the cutting edge.
- **Body posture**: Keep firm grip on tools, no reaching over work zone, two hands if necessary, stabilize tools with body if possible, maximize leverage
- **Securing work pieces**: use hand clamps, C-clamps, vise grips, or vises; *never* work holding a piece up in empty space. Clamp as close to work region as possible and keep your work pieces securbe so no slipping happens while you're working.
- **Sharp Edges**: *Always* file or deburr sharp edges with Dremel, deburring tool, etc. - cut metal edges can slice skin open very easily

Safety Quiz

1) When the teacher is not present, you may use tools _____
   a) If you have completed the tool certification
   b) Never
   c) You feel comfortable using the tool
   d) You are using the tool with a teammate
2) When working with materials with sharp edges such as metal and plastic, you must wear (select all that apply):
   a) Safety glasses
   b) Hair tie
   c) Gloves
   d) Steel-toed boots
3) If you are familiar with a tool, you may use it even if you have not passed the certification and been given permission by the instructor.
   a) True
   b) False
4) When should loose hair and clothing be pulled back or tied off?
   a) When using power tools
   b) When you are tired and less focused
   c) Only when your hair is really long or your clothes are really loose
   d) Always
5) Should water (or any liquid) ever be present around electronics?
   a) Yes
   b) No
6) When securing work pieces, you should always use what?
   a) Vise grips

b) C-clamps

c) Hand clamps

d) Vises

e) Any of the above

7) You should do what to sharp edges to avoid being cut?

a) Cut edges at a 90 degree angle so they're flat

b) File them

c) Sand them

d) Not use them

8) Which of the following describe the proper body posture you should have while using tools? (select all that apply)

a) Use two hands

b) Position yourself to maximize leverage

c) Maintain a firm grip

d) Stabilize tools with your body if possible

Tool Certification Chart

Team Name: _____ Team Number: _____ Date:_____

You will have a few opportunities throughout the season to demonstrate that you are able to safely use the power tools (and other tools if applicable as shown below)

Student Name	Hand Held Drill	Drill Press	Jig Saw	Hand Held Grinder	Chop Grinder	Circular Saw	Chop Saw	Soldering Iron

UNIT 2
Introduction to Robotics

UNIT OVERVIEW

UNIT NUMBER: 2 **DURATION: 20 hours**

SUMMARY

One important skill that students will learn in this course is design thinking. They will use the design process to brainstorm, plan, and implement a robot design. Due to the complex nature of robotics, without prior experience it can be hard to imagine a robot and subsequently to create a design. This unit will walk students through creating the basic pieces of a robot to familiarize them with the various parts and processes. They will not be told exactly how to build the parts, but tutorials will be provided at each step to provide guidance. They will be graded weekly based on their engineering notebook and Self and Peer Evaluations. Then they will move on to design and implement their own robot in the following units.

INSTRUCTIONS

1. Introduce the Engineering Notebook
2. Divide the class into two groups:
    1. Mechanical/Electrical Engineers
    2. Programmers
3. Groups will work simultaneously (and collaboratively) to create a basic robot.
4. The groups should first test the individual components before doing any building or programming.
5. Then the groups will begin building the robot. The Engineering team will complete the Mechanical/Electrical steps, while the Programming team will

LEARNING RESOURCES

Below are general learning resources. Specific tutorials related to this unit are in production and will be added when ready.

Engineering Resources

Modern Robotics Hardware Tutorials
Rev Hardware Tutorials
PushBot Guide
https://www.firstinspires.org/resource-library/ftc/robot-building-resources
Modern Robotics Core Device

complete the Programming steps. Many steps will require collaboration between the two teams.

Engineering Notebook Resources

Engineering Notebook Guidelines and Self-Assessment
Engineering.com Engineering Notebook Explanation

Discovery
How to Solder
Modern Robotics Sensors

Programming Resources

FIRST Tech Challenge Specific Resources
Java Tutorials
Blocks Tutorials
FIRST Tech Challenge GitHub Code

Java Resources
Codecademy Java Course
Learn Java Online

ASSESSMENTS:

1. Weekly Engineering Notebook
2. Weekly Self & Peer Evaluation

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Electronics parts
3. Soldering iron
4. Saws
5. Wrenches
6. Drill
7. Allen wrenches
8. Any and all power tools available

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

INTRODUCTION TO THE ENGINEERING NOTEBOOK

What is an Engineering Notebook?

An engineering notebook is formal documentation of the work of an engineer or engineering team on a specific design project. Engineers record ideas, inventions, experimentation records, observations and all work details in the engineering notebook. An engineering notebook can be used as a legal document to show the origin and evolution of an idea when seeking a patent.
One of the goals of *FIRST®* and *FIRST®* Tech Challenge is to recognize the engineering design process and the journey that a Team makes during the phases of the problem definition, concept design, system level design, detailed design, test and verification, and production of the robot. Throughout the process of designing and building a Robot, Teams will come across obstacles, lessons learned, and the need to draw things out on paper.

- What is the agenda for today?
- Why are you meeting?
- What are the goals for today?
- What decisions did your Team make in forming the Team, creating the robot, writing the program, the outreach projects, etc.?
- Why did you make that choice when building your robot, coded the software that way, chose that group of individuals to outreach to, etc.?
- What was the impact on your Team, robot, or community when you made that decision?
- What is the next step?

Anything and everything that documents a team's design process should be a part of the engineering notebook including:

- Written ideas
- Sketches (preferably annotated)
- Work session summaries
- Research findings
- Interview information: who was contacted, when, and what was discussed or learned
- CAD printouts
- Test Results
- Photographs
- Calculations

It doesn't matter if a line of investigation leads nowhere. Documented failures provide clues to success.

Students may choose to record their season with either handwritten, electronic, or online documents.

Electronic/Online: Teams may choose to use free website creation sites or Google Sites to create their Engineering Notebook. They may also choose to use Microsoft or Open Office Tools.

Handwritten: Teams can choose from spiral-bound, laboratory, or documentation notebooks available through their school or local stationary supply store. Teams can also use the binder supplied by Rockwell Collins delivered in the Registration and Welcome Kit.

For this course, you may decide to allow your students to choose their online format or your students may be limited to the handwritten option depending on their access to computers and internet. If your teams will be competing in official *FIRST* events, please make sure to review the Engineering Notebook guidelines.

The Engineering Notebook will be the primary source of grading in this course and should be reviewed by the teacher at regular intervals (preferably weekly) to assess each team's progress. Rubrics for grading the Engineering Notebook will be provided.

MECHANICAL/ELECTRICAL STEPS

Learn about the control system

1. Components of a Robot https://youtu.be/fU1GXteByJw

Set Up the Electronics

1. Connect the Driver Station to the Robot Controller https://youtu.be/LQqcX9rBX38
2. Power and Wire Your Robot https://youtu.be/DKwpEyKbTqM
3. Configure Your Robot https://youtu.be/VHyKE3B170k
4. Test your motors https://youtu.be/SOspcH58tZQ
5. Test your servos https://youtu.be/N6YulRyLmCQ
6. Test your sensors https://youtu.be/aZYBmU6ocec https://youtu.be/VAPxENrKRvo
7. Configure Your Gamepads https://youtu.be/mAivzV7jaRQ

Build a chassis

The chassis is the base or frame of the robot. Without the chassis, the rest of the robot has nothing to support it. The engineering team's first challenge is to: https://youtu.be/iv8qvimf-3A

Use beams, screws, and nuts to create a sturdy rectangle.
The rectangle should maintain it's shape and should not skew in any direction.
A rectangle is a good start to a chassis, but it will likely not be sufficient to hold all of the motors, servos, manipulators, and sensors that will go on the robot. Therefore, the team's next challenge is to:

Construct a frame that will hold all components of the robot securely and efficiently.

HINT:
You may also use the Pushbot Build Guide for assistance.

Construct a drivetrain

The drivetrain is what allows a vehicle or a robot to move. In order to move, a robot needs motors, wheels, and axels. The team's next challenge is to: https://youtu.be/28-VLKM3Wy0

Use set screws to mount a wheel on a motor.

Now it's a little hard to move or balance with only one wheel. Repeat this challenge for as many motors or wheels the team chooses. Some robots have 2, 3, 4, or even 6 wheels! Even if you only have 2 motors, you can use omniwheels that aren't attached to motors to help the robot maneuver. It also helps if the wheels and motors are attached to the rest of the robot. The team's next challenge is to:

Mount the motor/wheel combinations onto the robot.

HINT:
You may also use the Ranger Bot Movement Building Guide for assistance.

Mount electronics

Once the team knows how to connect all of the electronics, the parts need to be attached to the robot.

Mount the electronics onto the robot.

https://youtu.be/t1hK50_66zs

Wire management is important. Parts may get damaged if the wires are loose, pinched, or twisted. Now the team should:

Check the wiring to ensure safety and secure connections.

https://youtu.be/9u3Z0XrrXKQ

Build a Manipulator

The team should now have a good feel for how to connect beams, mount and connect parts, and design a basic robot. The last piece for this module will be to add a manipulator to the robot. A manipulator is simply an addition to the robot that is used to manipulate other objects. This could be an arm, a claw, a sweeper, or anything else the team can think of to help them complete the game's challenges! Typically manipulators are controlled using servos.

Build and attach a servo-controlled arm to the robot.

HINT:
The TETRIX Arm and Gripper Build Guide provides a good example of how to construct a manipulator.

PROGRAMMING STEPS

Getting started

There are a few things the team must do before they begin programming the robot. This will keep the programming team occupied until the engineering team can build enough of the robot to allow the programming team to test their code.

Select a programming language https://youtu.be/yGOIJG6d3g0

Install the software

In order to begin programming, the appropriate software must be installed on the team's computer(s). Which software to use depends on which programming language the team is using. The instructions can be found here:

- Java Installation Instructions https://youtu.be/mMrC5kDcUN4
- Blocks Installation Instructions https://youtu.be/AKoqwqPo-Vc https://youtu.be/BL0kvoQcjxU

Learn basic programming skills
If the team is new to programming and is using Java, it may help to learn basic programming skills before jumping into robot programming. This course from Codecademy.com will give the students a great introduction.

Learn about *FIRST* Tech Challenge programming
If the team is new to *FIRST* Tech Challenge, it may be helpful to learn how the technology works.

What is a robot? https://youtu.be/yDvZHnH5t-4 **What is an op mode?** https://youtu.be/PvCTwPDyen8

Op Modes

How do I write an op mode?
https://youtu.be/7CDK5-m-vQw https://youtu.be/o-7z9WE6JAI

How do I install an op mode onto my robot?
https://youtu.be/cRcdGPaZ70Y https://youtu.be/uItHYCxT9eY

Moving

Now the team is ready to start programming the robot! Here are the first challenges the team should overcome:

Program the robot to move forward.

Program the robot to move backward.

Java https://youtu.be/dNiGzPqEF9I **Blocks https://youtu.be/f8-NQIS3IEM**

Turning

Moving forward and backward is great, but the playing field requires the robot to move on more than one dimension. Next the team should:

Program the robot to turn 90 degrees to the left.

Program the robot to turn 90 degrees to the right.

Java https://youtu.be/Xpgs3UKDiW8 **Blocks** https://youtu.be/PuOKjimrJ0k

---

Implement Gamepads

When using a gamepad, it is very useful to be able to move the robot at multiple speeds. Bring on the next challenge!

Program the robot to adjust its speed based on the position of the remote control's joysticks.

Java https://youtu.be/-w_d508l7P8

Blocks **https://youtu.be/8KXQketfarE** **Blocks** **https://youtu.be/75ndVZzZJjU** **Blocks** **https://youtu.be/tQW8ZG6B_bQ**

Rotate Servos

The gamepad must control every aspect of the robot, not just the movement. Anything controlled by a motor or servo should have a corresponding gamepad control.

Program the gamepad to rotate any and all arms, levers, pulleys, or other servo or motor controlled mechanisms on the robot.

Java https://youtu.be/-J7RNUxm_p8 **Blocks** https://youtu.be/Qd8iMiAkFGI

Drive in a square

The *FIRST* Tech Challenge game begins with a 30 second autonomous period. This means the robot must act completely on its own for 30 seconds. How is the robot supposed to know where it is or where to go? Good question! There are many different ways, but the tutorial with the challenge below shows the most basic way for beginners.

Autonomously drive along the perimeter of a 5'x5' square.

Autonomously drive along the perimeter of a 10'x10' square.

Java https://youtu.be/BLYqh_svu8Q

Helpful Tips

https://youtu.be/YDEkcunllYI https://youtu.be/fgGMq7ulXP4

UNIT 3

FIRST® Tech Challenge Game

UNIT OVERVIEW

UNIT NUMBER: 3 **DURATION: 10 hours**

SUMMARY

In order to solve a problem, one must first understand it. For building a competing robot, the problem is defined by the *FIRST*® Tech Challenge game. In this unit the students will research and learn about the *FIRST* Tech Challenge game and begin the early stages of the design process with preliminary planning and strategizing.

INSTRUCTIONS

1. Watch the *FIRST* Tech Challenge release video and present this unit's driving question.
2. Discuss Knows and Need-to-Knows.
3. Divide students into groups and have them research the game manuals (found here).
4. Groups will present their findings and related quiz questions.
5. Prepare a quiz using the student-created questions.

Give students the quiz.

ASSESSMENTS:

1. Group Presentation of Game Manual section with rubric
2. Quiz over rules (3 questions from each group)
3. Weekly Engineering Notebook

TOOLS & MATERIALS

No tools or materials needed for this unit.

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

ENTRY EVENT

Watch the Challenge Kickoff Video!

DRIVING QUESTION

What do we as engineers need to know about this year's *FIRST* Tech Challenge game in order to design an effective robot?

HINT:
Driving questions are a Project-Based Learning mechanism designed to foster inquiry in students. The idea is to present students with an engaging and open-ended problem or challenge that will cause them to begin asking questions. Your job as the teacher is to then facilitate the students' process of finding the answers. See this page for more information on Driving Questions.

KNOWS

HINT:
Knows and Need-to-Knows are another Project-Based Learning mechanism. Once the entry event and driving question have been presented, the students should have questions. There are things about the project they already know, and there are undoubtedly many things about the project they will need to know or learn in order to complete it. Ask the students questions (or even better, let them ask questions) to help them think through what they currently know and what they will need to know.

As a class, make a list of what the students currently know related to the project. Ask questions such as:

1. What do we know about the driving question?
2. What do we know about *FIRST*® Tech Challenge?
3. What do we know about building a robot?
4. What do we know about programming?
5. What do we know about this year's game?
6. And more!

NEED-TO-KNOWS

Now make a list of what students need to know to complete the project. Ask questions such as:

1. What do we *not* know about the driving question?
2. What do we *not* know about *FIRST* Tech Challenge?
3. What do we *not* know about building a robot?
4. What do we *not* know about programming?
5. What do we *not* know about this year's game?
6. And more!

This list will help as the students design and build the robot. Have them think about how they can learn the things on this list. Where can they go? What resources can they access? Who can they talk to?

GAME RESEARCH

1. Divide students into groups of 3.
2. Assign each group a different section of the game manual. The sections of the game manual include:
    1. The Tournament
    2. The Robot
    3. Robot Inspection
    4. Judging & Award Criteria
    5. The Game
3. Have groups research their section of the game manual.

4. Groups will prepare a 5 minute presentation answering the driving question in relation to their section of the manual. The presentation should:
    1. Go beyond a verbatim reading of the rules.
    2. Analyze the rules and the implications they will have on the robot design.
    3. Discuss possible complications and strategies. For example:
        1. Propose a scoring strategy
        2. What does the robot need to accomplish?
        3. How can the robot be designed to accomplish the tasks?
        4. What interesting things have teams done in the past?
        5. Are any of the rules vague? If so, what freedom or constraint does that place upon the robot design?
    4. Create 3 quiz questions based on your section of the manual. These will be combined from all groups and given to the class for a grade.
5. View the presentation rubric.

GAME MANUAL PRESENTATION

Prepare a 5 minute presentation answering the driving question in relation to your section of the manual. The presentation should:

1. Go beyond a verbatim reading of the rules.
2. Analyze the rules and the implications they will have on the robot design.
3. Discuss possible complications and strategies. For example:
    1. Propose a scoring strategy
    2. What does the robot need to accomplish?
    3. How can the robot be designed to accomplish the tasks?
    4. What interesting things have teams done in the past?
    5. Are any of the rules vague? If so, what freedom or constraint does that place upon the robot design?
4. Create 3 quiz questions based on your section of the manual. These will be combined from all groups and given to the class for a grade.
5. Printable version available https://my.pblworks.org/resource/document/6_8_presentation_rubric_non_ccss.

UNIT 4

Initial Design

UNIT OVERVIEW

UNIT NUMBER: 4 **DURATION: 10 hours**

SUMMARY

In this unit, students will begin the design process. You will introduce the design process with a short activity, and then the students will go through the first three steps of designing their robot: identifying the problem/requirements, brainstorming, and planning.

INSTRUCTIONS

1. Use the PBS Paper Table Challenge as an entry event and present the driving question to the students.
2. Discuss Knows and Need to Knows.
3. Divide the students into groups and start them on their robot design challenge.
4. Groups will present their designs to the class at the end of the week and the students will give feedback on each others' ideas.
5. As a class, decide on a "final" plan.
6. Students will complete Self & Peer Evaluations.

LEARNING RESOURCES

PBS Design Process
Paper Table Challenge Teacher Guide
Paper Table Challenge Sheet
Science Buddies: Engineering Design Process

ASSESSMENTS:

1. Weekly Engineering Notebook
2. Weekly Self & Peer Evaluation
3. Design Presentation

TOOLS & MATERIALS

Paper Table Challenge

1. Newspaper
2. Masking tape

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

ENTRY EVENT

Use newspaper and masking tape to build a table that will hold a textbook!

Use this Paper Table activity from PBS to introduce the design process. In groups, students must use newspaper and masking tape to build a table that will support a textbook without collapsing or falling over.
After the activity, discuss the design process. The design process consists of five stages:

1. Identify a problem
2. Brainstorm ideas
3. Design and plan a solution
4. Build a prototype
5. Test the prototype

The stages are a cycle. Once the team has built and tested their design, they will inevitably need to make changes. These changes then become the problems they address for the next cycle of the design process. They will brainstorm ideas for how to solve these problems, design a solution, build it, test it, and repeat. There are always improvements to be made! This cycle continues until the end of the *FIRST* Tech Challenge season.
If you would like more guidance on facilitating a discussion about the design process with your students, check out this discussion guide from PBS.

DRIVING QUESTION

How can we as engineers design a robot to compete in the *FIRST* Tech Challenge?

Complete knows and need to knows again. Many of the questions may be the same as the previous unit, but it can't hurt to reassess what we know and don't know!

KNOWS

As a class, make a list of what you currently know related to the project. Ask yourselves questions such as:

1. What do we know about the driving question?
2. What do we know about *FIRST*® Tech Challenge?
3. What do we know about building a robot?
4. What do we know about programming?
5. What do we know about this year's game?
6. And more!

NEED-TO-KNOWS

Now make a list of what you need to know to complete the project. Ask yourselves questions such as:

1. What do we *not* know about the driving question?
2. What do we *not* know about *FIRST* Tech Challenge?
3. What do we *not* know about building a robot?
4. What do we *not* know about programming?
5. What do we *not* know about this year's game?
6. And more!

This list will help as you design and build your robot. Think about how you can learn the things on this list. Where can you go? What resources can you access? Who can you talk to?

DESIGN CHALLENGE

1. Divide students into groups of 3-4.
2. Instruct the students that they have one week to create a robot design by following the first three steps of the design process.
    1. Identify a problem (much of this work was done in the previous unit)
    2. Brainstorm ideas
    3. Design and plan a solution
3. Remind them to continually document their process in the Engineering Notebook!

HINT:
Much of the work for identifying a problem and some of the brainstorming was done in the previous unit when students researched the *FIRST* Tech Challenge game.

PRESENTATIONS & CRITICAL FRIENDS

1. At the end of the week, have each group present their plans to the rest of the class.
2. After each presentation, have students perform "Critical Friends." Critical friends is a way for students to give feedback on others' ideas in a constructive way. It works like this:
    1. Students ask the presenting group clarifying questions to make sure they fully understood the presentation.
    2. After step 1, the presenting group can no longer speak, but only listen.
    3. Students then share what they like about the ideas presented.
    4. Then students may raise concerns or questions they have about the ideas. This is done by asking "I wonder" questions. For instance:
        1. I wonder if having 4 wheels will provide the power needed to climb hills?
        2. I wonder if the robot is tall enough to reach the bar?
    5. Now the presenting group may speak again and talk about ways they could improve their design based on the class' "I wonder" questions.
    6. Finally, the class may suggest other ideas by saying "I have..."
    7. This video provides an overview of the Critical Friends protocol.
3. After all of the groups have presented, facilitate a team-wide discussion on what design to use for the robot. It is perfectly acceptable to mix and match ideas from different groups.

HINT:
Help the team decide on a decision-making process they will use throughout the season.
1. How will they make decisions?
2. Are there designated leaders?
3. Will they use a majority vote?

This will help avoid conflict later in the process.

UNIT 5

Building & Programming

UNIT OVERVIEW

UNIT NUMBER: 5

DURATION: Iterative until end of semester or the end of competition (whichever comes later)

SUMMARY

In this unit, students will begin building and programming the robot designed in the previous units. They will implement the rest of the design process (prototype, test, redesign), and through this process will learn about working with hardware, electronics, and programming. They will build and program the robot and then test it to see where it fails. Then they will go back to the drawing board to design and implement improvements. The programming and engineering teams will work closely to make sure the physical design and software design are always in sync.

INSTRUCTIONS

1. Have students create a project timeline.
2. Students will then use the design process to build the robot. They will:
    1. Build and program the prototype.
    2. Test the prototype.
    3. Redesign the robot.
3. Students should use the Knows and Need-to-Knows listed in the previous modules to guide their learning.
4. Students should access engineering and programming tutorials included in this unit and

LEARNING RESOURCES

Below are general learning resources. Specific tutorials related to this unit are in production and will be added when ready.

Engineering Resources

Modern Robotics Hardware Tutorials
Rev Hardware Tutorials
Robot Building Resources
How to Solder
Modern Robotics Sensors

previous units, as well as online resources to gain the skills they need.

5. Remind students that they must:
    1. Document everything in the Engineering Notebook.
    2. Demonstrate safe use of a tool to you before using it in the build process.

Programming Resources

FIRST Tech Challenge Specific Resources

Java Tutorials

Blocks Tutorials

FIRST Tech Challenge GitHub Code

Java Resources

Codecademy Java Course

Learn Java Online

ASSESSMENTS:

1. Weekly Engineering Notebook
2. Weekly Self & Peer Evaluation

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Electronics parts
3. Anderson Power Pole
4. Soldering iron
5. Saws
6. Wrenches
7. Drill
8. Allen wrenches
9. Any and all power tools available

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

CREATING A PROJECT TIMELINE

Robot Order of Operations
Have the team create progressive deadlines between now and your first competition. Even if your team(s) are not competing, deadlines are still a vital project management skill for students to learn. Major milestones are listed below, but your teams should be much more specific.

1. Design the Robot
2. Build the Robot frame
3. Attach the Android phones
4. Lay out the wiring and draw a wiring diagram
5. Wire the Robot
6. Program the Robot
7. Test the Robot
8. Make adjustments
9. Repeat

Specific Tasks
Teams should take the major milestones and break them up into small tasks. This list should include everything that needs to be done throughout the season. Helpful questions may be:

1. What is involved in completing this milestone?
2. How many parts are included?
3. How does this design fit into this milestone?
4. What materials are needed for this task?

This process is often difficult for new teams because they don't always know what is involved until they get farther into the work, but that's okay. The plan may change along the way, but this will help the students learn to plan and think through the process beforehand. If they don't plan beforehand, they will get distracted, make design changes too late in the process, fall behind their deadlines, and ultimately fail to finish on time.

Due Dates
The team should then assign due dates to each of the tasks listed. Helpful questions may be:

1. How long will this task take?
2. What needs to be done before this task can be started?
3. Which team members will be responsible for this task?

The team should refer to these dates on a daily basis to make sure they are on track. If they are, congratulate them! If not, help them figure out how they can catch up or adjust their deadlines.

ADVANCED ENGINEERING SKILLS

The following challenges are not required, but may be useful if it applies to the team's robot design.

Using gears

Gears are a great way of adding power to a robot.

Use gears to increase force to the robot's drivetrain or servo-based manipulator.
https://youtu.be/0W1q1_hU57g

Creating a motor-powered pickup system

Design a motor-powered system to pick up objects.

Creating a motor-powered pickup system - In the video below, Robot in 3 Days shows their end effector design to pick up objects for the 2015-2016 season.
https://youtu.be/JMwx87KibR4

Creating a lift system

The *FIRST*® Tech Challenge robot must begin the competition by fitting in an 45.72mm (18 in.) cube, but it may then expand to any size it needs to accomplish the tasks of the game. Expansion is necessary to reach field objects and do things such as climb hills and hang from bars.

Use a 4-bar linkage, rack & pinion system, scissor lift, or another unique design to build a manipulator that expands beyond the 45.72mm^3 (18 in$^{3)}$ starting size.

Creating a lift system - There are many ways to design lift systems. In the video below, Robot in 3 Days shows their design for the 2015-2016 season. https://youtu.be/JMwx87KibR4

Mitigating electrostatic discharge

Robots can sometimes create an electrostatic charge while moving around on the playing field. This can cause problems in the way your robot functions, so certain design principles can be used to mitigate such discharge.

Mounting encoders

Encoder kits contain instructions on how to mount them onto the motors. Use these instructions to mount your encoders. The general steps are:

1. Use M3 screws to screw the encoder base to the Tetrix motors.

2. Then place the optical disk with the pattern side down (so that the LED on the encoder base will shine onto that surface) and use the spacer tool to slide the disk into place. (Hint: Users should be careful not to touch the optical disk and leave fingerprints.)
3. Then, snap the cover in place and plug in the connector cable.

Rev Inertial Measurement Unit

https://youtu.be/eN7fQnQ8zeg

Advanced Hardware Setups

https://youtu.be/gBHW4kVQsiM

https://youtu.be/U3E5AM56xzg

https://youtu.be/7rbLDden-Rs

DEMONSTRATING TOOL SAFETY

The following challenges are not required, but may be useful if it applies to the team's robot design.

Stopping on a line

Place a line of tape on the ground. Program your robot to move forward until it reaches the line, and then stop.

Java - Using an Optical Distance Sensor https://youtu.be/44UlKiU_8us

Blocks - Using a Color Sensor Part 1 https://youtu.be/iQufRF1HFRc
Blocks - Using a Color Sensor Part 2 https://youtu.be/uSEEO3_JVTI

Stopping on different color lines

Place another line three feet behind the first line using a different color of tape. Program your robot to distinguish the difference between the colors. The robot should NOT stop when it reaches the original line, but should stop upon reaching the new line.

Stop a certain distance from an object

Program the robot to stop at a specific distance from an object.

Stop when touching an object

Program the robot to stop when it has touched an object.

Using touch sensor

https://youtu.be/r2ZanwiETj0

UNIT 6

Reflection and Improvement

UNIT OVERVIEW

UNIT NUMBER: 6

DURATION: Approximately 12 in-class hours or iterative until the end of semester or postseason participation

SUMMARY

In this unit, students will complete a process to reflect on and evaluate their accomplishments with the *FIRST* Tech Challenge Game. They will identify a clear, demonstrable goal for improvement on **one** aspect of robot or team performance and develop a plan to execute and test the improvement for impact. Upon completion of this process, students will use the criteria they have outlined to evaluate their success. They will then develop a short Performance Impact presentation to share their experience with another team, class, parent group, sponsor, or other interested group community member.

INSTRUCTIONS

1. As a class reflect on student progress throughout Units 1-5. Ask each student to share their proudest moment or greatest success. Take some time to celebrate and document these achievements! These represent some of the team's strengths and may provide insight into which areas of improvement could have the greatest impact.
2. Present students with the "Second Chance" scenario and Driving Question.
3. Divide the class into small groups of 2-3 students to brainstorm and identify an aspect of robot design, programming, or strategy that could have a significant, positive impact on performance. This may involve correcting a current problem, building upon an existing strength, or trying a completely new approach.
4. In groups, or as a class (depending on the desired improvement and available resources), create a plan to complete and test the redesign. Don't forget to document the current iteration of that aspect before making the change.

LEARNING RESOURCES

Game and Parts Resources

- Archived Game Documentation
- Team Management Resources

Project Based Learning Resources

- Project Based Learning Information, Rubrics, and Resources from the Buck Institute for Education
  - Project Based Teaching Practices
  - Project Based Teaching Rubric
  - Project Design Rubric
  - 6-12 Creativity & Innovation Rubric (CCSS Aligned)

***FIRST* Tech Challenge Mentor Resources**

- https://www.firstinspires.org/resource-library/ftc/team-management-resources

5. Complete and test the redesign. This can be completed in small groups if several kits are available to modify and test, but may need to be completed as a class if everyone is working on the same robot or process for improvement.
6. In groups or as a class, determine the impact of the redesign and complete a Performance Impact summary to share the results and experience with other groups or with the community.

ASSESSMENTS:

1. Make a Decision
    1. Templates
    2. Rubric
2. Make a Plan Templates
    1. Templates
    2. Rubric
3. Performance Impact Templates
    1. Templates
    2. Rubric
4. Weekly Engineering Notebook
5. Weekly Self & Peer Evaluation

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Electronics parts
3. Soldering iron
4. Saws
5. Wrenches
6. Drill
7. Allen wrenches
8. Any and all power tools available

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

ENTRY EVENT & DRIVING QUESTION

Second Chance Scenario

What would you do if you had more time? Imagine that a prestigious postseason bonus tournament will be taking place in your area: the "Second Chance Championship." The competition is open and the game challenge is the same, but not just anyone can participate.

To gain entrance into the tournament, your team must demonstrate a documented attempt to improve your robot, programming, or team play. The overall goal is to generate an **observable, positive impact** on performance. You have one month to select an area for improvement, implement the change, and prepare your team for a "Second Chance Championship."

Driving Question

How can we, as a team of engineers, generate a significant, positive impact on our performance in the *FIRST* Tech Challenge and earn a place in the Second Chance Championship?

HINT:
The goal of this challenge is not to guarantee a win, but to make a well-conceived and well-documented effort to make the robot, programming, or team play **observably better** than it was before. Progress in the real world of engineering doesn't always happen with a grand slam or a win. It comes one small improvement (and several setbacks) at a time. Teams may choose to build upon an existing strength, correct an existing problem, or try a new approach they didn't have time for or simply didn't think of before.

Understanding Impact
Select a simply constructed object in the room, such as a chair, a table, or a bookshelf. Discuss its function and how well it performs that function.

As a class, talk about what a significant improvement might look like for this object. Remember that the improvement must be observable and must have an impact on that item's performance.

For example, a chair in the classroom could be improved visually by changing its color, or the material it's made of. If the chair's performance task is to be supportive and comfortable, would these improvements have a significant impact on its performance of that task? Maybe, but modifying the shape of the seat, or its height, or the placement of the backrest, might have a more significant impact on that performance.

Guiding Questions:

- How is the chair performing now?
- What works well and what doesn't?
- What could be improved? (e.g., style, color, shape, height, material, durability)
- How big a difference would that improvement make on the chair's actual function?
- Would there be any negative consequences to that improvement? (e.g., weight, too big for space, expensive, don't have the material or know how to do it)

HINT:
When discussing the current performance or condition of a given item, it's a good idea to include some discussion about the cost of making, fixing, or purchasing that item. There are usually reasons, beyond basic design, that something may not work as well as it could (e.g., cost of materials or manufacturing). For this activity, these reasons can be discussed as important considerations in the real world of engineering, and then removed

	as limitations for the brainstorming process to encourage broader thinking about the problem.

Facilitator's Tips

Q: What kinds of improvements can be made?

A: As a facilitator, it's important to support students as they generate their own ideas for improvements, based on their experience with the *FIRST* TECH Challenge Game. Listed below are some guiding questions and suggestions for students to investigate in their Engineering Notebooks and discuss as a class.

Guiding Questions for Technical Improvement Goals:

- How can we make the robot more reliable?
- How can we make the robot faster?
- How can we make the robot more accurate?
- How can we make the robot easier to control/maneuver?
- How can we make the robot more powerful?
- How can we make the robot more stable?
- How can we make the robot more resilient?

Guiding Questions for Non-Technical Improvement Goals:

- How can we improve our game strategy?
- How can we improve our time management?
- How can we improve our workflow or process of development?
- How can we improve our tracking or documentation of results?
- How can we work together more effectively?
- How can we distribute work more effectively?
- How can we improve access to different opportunities within the team?

Q: Must the improvement involve technical changes?

A: Yes and no. Because the improvement will ultimately be assessed based on the performance of the robot and team in the challenge, the robot and programming will be involved. However, it may be the case that the robot and programming stay largely the same, but the way in which the team works together, or the development of a stronger, more diverse team would result in new ideas or untapped talents being integrated into game play. Encourage team players to take on new roles. Try switching the presentation crew and the drivers, or give the programmers a chance to revise the game strategy. Mix up teams between classes or give one group the chance to experiment with or play with another group's robot. Every team has untapped talent. This unit in the postseason period is a great opportunity to identify that potential and Unit 7: Skill Building is a great place to develop it.

To learn more about identifying biases and how they affect equitable participant engagement, *FIRST* Tech Challenge has developed a Schoology module called FTC Volunteer Training: Invisible Inequities Course. Teachers and mentors can join the course by searching the course title and using the access Code: BRXDP-2ND8V.

REDESIGN CHALLENGE

Focused Improvement

Have students work in small groups to identify three specific aspects of robot design, programming, or team performance that they feel could be improved. If possible, encourage students to work in mixed groups that include individuals who participated in different aspects of robot design or team play (e.g., a builder, a programmer, a driver, a manager).

Consider reviewing:

1. Content of Engineering Notebooks
2. Robot development process
3. Videos of games or competitions with the robot

4. Robot performance or statistics
5. Team performance and roles on the team

HINT:
Encourage students to review video footage of competition, notes, and ideas from their team's Engineering Notebook. Make sure to include discussion about personal experience and frustrations as the game was executed.

Use or adapt the Make a Decision resource to have students brainstorm and evaluate ideas for **focused** robot performance or team improvement. The end goal is to focus on **one** aspect of robot design, programming, or team play that could have a significant and observable impact on overall performance in the *FIRST* Tech Challenge game.

Encourage students to consider the **value** of the improvement as well as any negative consequences or ripple effects on other aspects of design or team play.

Two different templates have been provided in the form of a mind map and an organization chart template in the Make a Decision resource. Students may choose the template that best supports their own brainstorming style. The headers provided on the templates have been selected to support students as they consider the kinds of Guiding Questions below, but teachers should feel free to encourage students to generate their own headers or to modify the word doc templates to include specific key questions for students who need more defined direction.

Guiding Questions:

1. What will it solve?
2. Is this problem a big problem or a small problem?
3. Will this improvement correct a problem or further develop and enhance an existing capability?
4. What kind of impact will it have on performance?
5. Will the impact be observable? How?
6. Are there any negative consequences to making this kind of change?
7. Is the improvement permitted in the rules for this year's game?
8. Has the improvement been permitted in the rules of previous games?
9. Is it likely to be permitted or useful in future games?
10. Do you have enough time to do it?
11. Do you have the resources you need to do it?
12. What do you have to learn or know to do it?
13. What other aspects of the robot design or team performance will this impact?

Answering these questions will help students to decide which aspect of robot design, programming, or team performance they would like to improve.
Let students know that they will be creating a short presentation on the impact of their attempted improvement at the end of this unit. They will need to include details about their robot or team performance **before** and **after** the improvement was attempted, so it's important to make sure their anticipated outcomes are **measurable** and **observable**.

A rubric for this activity has been provided in the Unit 6 Rubric resource.

Redesign Facilitator's Tips:

Q: Do we have to choose just **one** aspect to redesign?

A: There is no limit to how many improvements can be suggested or made, but **how** they are completed will depend on resources, class time, and the kinds of improvements students are driven to attempt.

If more than one improvement is selected, it may be a good idea to complete one change at a time so that the impact of the improvement can be clearly observed before moving on to the next.

If resources or the number of kits are limited, it may be a good idea to have small groups each think through and plan a different solution and then revisit the "Critical Friends" protocol from Unit 4: Initial Design to come to a class or group consensus about which focused improvement idea should be executed and tested.

If resources (specifically the number of kits) and time allow, students may wish to divide into groups and each attempt a different improvement or aspect of design to improve. A culminating activity could then be completed to test and select the improvement that has the greatest impact. In this case, it would be important to make sure that the starting point for each group rests on the same strategy, design and programming.

Q: What resources exist to assess the value of the improvement for future game play or challenges?

A: It may be a good idea to review the games from previous years to see if the improvement being proposed would have been useful for those challenges. Some aspects of design or programming, such as gripping extensions or object-oriented programming, will appear frequently. Other aspects, such as improved connectivity with mobile devices, may have appeared more recently in competition needs and are likely to continue to be useful.

Past season games can be found in the Archived Game Documentation on the *FIRST* Tech Challenge website.

Information regarding the legality of parts or approaches can be found in the Game Manual for each year, and in the Team Management Resources in the *FIRST* Tech Challenge Resource Library.

Note that the legality of parts and software will vary from year to year.

PLANNING

Create a Timeline

Think about the steps and resources needed to complete the improvement. Use one of the Make a Plan templates or have students create their own timeline of tasks, resources and responsibilities to make the improvement. Depending on the improvement selected, there may be a clear, linear path to follow, or there may be several tasks that will overlap and flow between each other.

Use the planning tool or tools that best suits your students' needs.

HINT:
You may want to revisit some of the steps and tasks involved in "Creating a Project Timeline" from Unit 5: Building and Programming. Remember that the task in Unit 6 is much more focused (**one** aspect of design or performance). The order of operations and tasks may be very similar to Unit 5, but the templates for Unit 6 have been created to abbreviate this process slightly.

Ongoing Review

How will you know if the improvement is being completed in line with your original goals for impact?

1. Document the "before" state of your robot, programming or performance.
    - Take a video
    - Take pictures
    - Take screen shots of programming or current CAD designs
2. Create a checklist of observable outcomes (Performance Impact Criteria) to assess whether the improvement is having the desired impact on performance.

    Use the template provided in the Performance Impact resource or have students create their own. The templates have been created to add picture or text details as needed.

Guiding Questions for the Creation of Checklist Criteria:

- Does the robot/extension/program run/move/execute X% faster?
- Does the robot/extension/program/team process complete its function reliably X times out of X?
- Does the robot/extension/program reach X% further?

- Is the robot/extension more stable or resilient? Can it complete its task X times out of X without tipping over or coming apart?
- Do we make more, the same number, or fewer errors this way?
- Does the robot/extension/program/team process/strategy operate X% more precisely or effectively? Do we have fewer collisions or driving errors?

Before making the changes, use the template provided or make your own checklist of markers of success on the Performance Impact resource. Decide, as a class, how many of these markers should be achieved for an observable impact to be demonstrated.

A rubric for this activity has been provided in the Unit 6 Rubric resource.

Planning Facilitator's Tip:

Q: Is it important to stick to the plan?

A: The development of organization and time management skills is a critical part of the *FIRST* Tech Challenge experience and it's important to work towards those goals. It's also important to give students the opportunity to learn to think and work flexibly when the situation calls for it. During the redesign process, it's possible that students will change paths on the redesign they've planned. Depending on the significance of the change, it may be necessary to pause, regroup, and revisit the timeline and plan for completion.

REDESIGN

Make the Change

Have students execute the redesign and the plan they've created. Make sure to revisit the plan, timeline and performance impact criteria frequently. The plan may change, but it's important to revisit the overall goals to keep on track.
Add notes, pictures, or links to the plan and checklist. These can all be included in your Engineering Notebook to demonstrate team progress and growth. They will also become an important resource for the Performance Impact presentation at the end of this unit.

Redesign Facilitator's Tip:

Q: How can focus be maintained over the course of the Unit?

A: It is typical for a design to evolve as it is developed and ideas are fleshed out and tested. However, it's important to return to the overall goals and desired impact of the improvement frequently. It's a good idea to begin each class or session with a review of the desired impact of the improvement and the criteria that have been selected to indicate that the changes are having the desired impact.
Templates for checklists and documentation of impact criteria have been provided in the Performance Impact resource for this unit.

IMPACT

Have students test the improvement and revisit the Performance Impact checklist that they created in the Planning phase of this unit. An important piece of Project-Based Learning is for students to share their learning in some way. This can be done in many ways; limited only by resources, time, and student interest. The key pieces to include are an explanation of the desired improvement, a representation of the anticipated impact, and a representation of the actual impact, as well as documentation of any unexpected or surprising learning.

The desired outcome is an engaging, visual, or interactive presentation that allows students to share their latest success. Presentations should be brief and light-hearted.

Some suggestions for impact presentations include:

- Before and after Impact Summary (provided in the Performance Impact resource with this unit) can be shared in *FIRST* Inspire forums or with other teams to demonstrate a problem solved by the team, that others may be interested in.
- Before and after videos of performance shared on a team or school website.
- Info-graphics created using online tools or graphic design software.
- Visual representations of statistics or graphs of results formatted to be easily interpreted by community members.
- Live demonstrations and oral presentation of achievements with others in the school, parents, or the *FIRST* Inspire community.

Guiding Questions:

- How many markers of impact were achieved?
- Were there any negative impacts in other areas of design or performance that resulted from the improvement?
- Did the plan or the intended improvement change?
- Did you learn anything that surprised you?
- Were there any surprising results?

Return to the original "Second Chance Competition" scenario and Driving Question. Invite school staff or other classes to take part in student presentations and weigh in on whether the improvement completed has made a significant and observable impact on performance.

If time and resources allow, organize a "Second Chance" scrimmage or mini-tournament with another team or between groups within a class to redo the *FIRST* Tech Challenge game with their new and improved robot, program, or team play.

A rubric for this activity has been provided in the Unit 6 Rubric resource.

Impact Facilitator's Tips:

Q: How can the impact be documented?

A: Make sure to document the **before** state of your improvement, as well as the **after** state.

- Throughout the process, schedule documentation dates so that smaller developments, ideas and errors aren't missed.
- Make a video, take pictures and screenshots.
- Have students complete a video journal entry each session using a smart phone.
- Use the templates provided with this unit. They can be modified to suit your students' learning or presentation styles and allow for text information or pictures to be added. Use them "as is" or as a starting point for students who are learning to organize their ideas visually and present information in a variety of ways.
- Add documentation to the Engineering Notebook to demonstrate and document team growth and development.

Q: How can this presentation be used to reach long term team goals?

A: Effective documentation and presentation of progress are valuable skills for students personally, and the overall experience of the *FIRST* Tech Challenge emphasizes these real world, non-technical skills as part of the competition. Striving towards and demonstration of sincere efforts to improve and develop new skills can help teams in their search for sponsors, in recruitment efforts, and potentially, in efforts to earn *FIRST* Tech Challenge awards outside of game play.

FIRST Tech Challenge celebrates efforts outside of game play with a number of awards. Efforts in this year's postseason may help teams attain these awards in the future.

Make a Plan

Unit 6: Reflection and Improvement

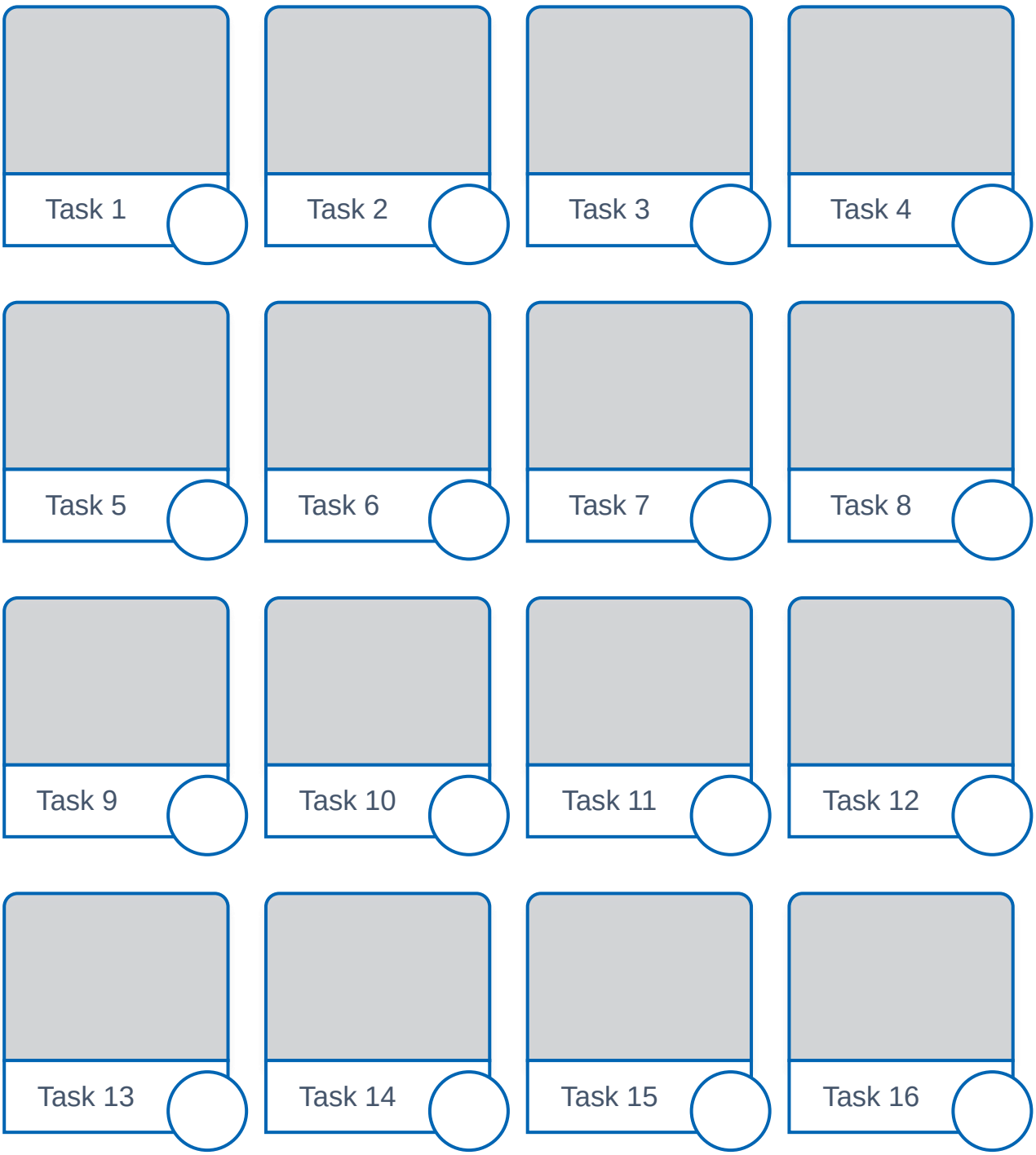
Use the template below or make your own timeline or checklist to complete the improvement you and your team have selected to impact your performance.

Task	Resources Needed	Estimated Completion Date	Team Members Responsible

Make a Plan

Unit 6: Reflection and Improvement

Use the template below or make your own timeline or checklist to complete the improvement you and your team have selected to impact your performance.



Make a Plan

Unit 6: Reflection and Improvement

Use the template below or make your own timeline or checklist to complete the improvement you and your team have selected to impact your performance.

Task 1

- [ ] Subtask 1
- [ ] Subtask 2
- [ ] Subtask 3
- [ ] Subtask 4
- [ ] Subtask 5
- [ ] Subtask 6
- [ ] Subtask 7
- [ ] Subtask 8

Task 2

- [ ] Subtask 1
- [ ] Subtask 2
- [ ] Subtask 3
- [ ] Subtask 4
- [ ] Subtask 5
- [ ] Subtask 6
- [ ] Subtask 7
- [ ] Subtask 8

Task 3

- [ ] Subtask 1
- [ ] Subtask 2
- [ ] Subtask 3
- [ ] Subtask 4
- [ ] Subtask 5
- [ ] Subtask 6
- [ ] Subtask 7
- [ ] Subtask 8

Task 4

- [ ] Subtask 1
- [ ] Subtask 2
- [ ] Subtask 3
- [ ] Subtask 4
- [ ] Subtask 5
- [ ] Subtask 6
- [ ] Subtask 7
- [ ] Subtask 8

Make a Decision

Unit 6: Reflection and Improvement

Make a list of things your robot or team does well. Write or draw as many ideas as you can fit in each box.

Robot Design	Programming	Strategy or Team Performance

Make a list of things your robot or team does **not** do well. Write or draw as many ideas as you can fit in each box.

Robot Design	Programming	Strategy or Team Performance

Choose **three** areas of improvement from these ideas that you think would make your team or robot perform **better**.

Circle them.

Now think about the **impact** these improvements would have.

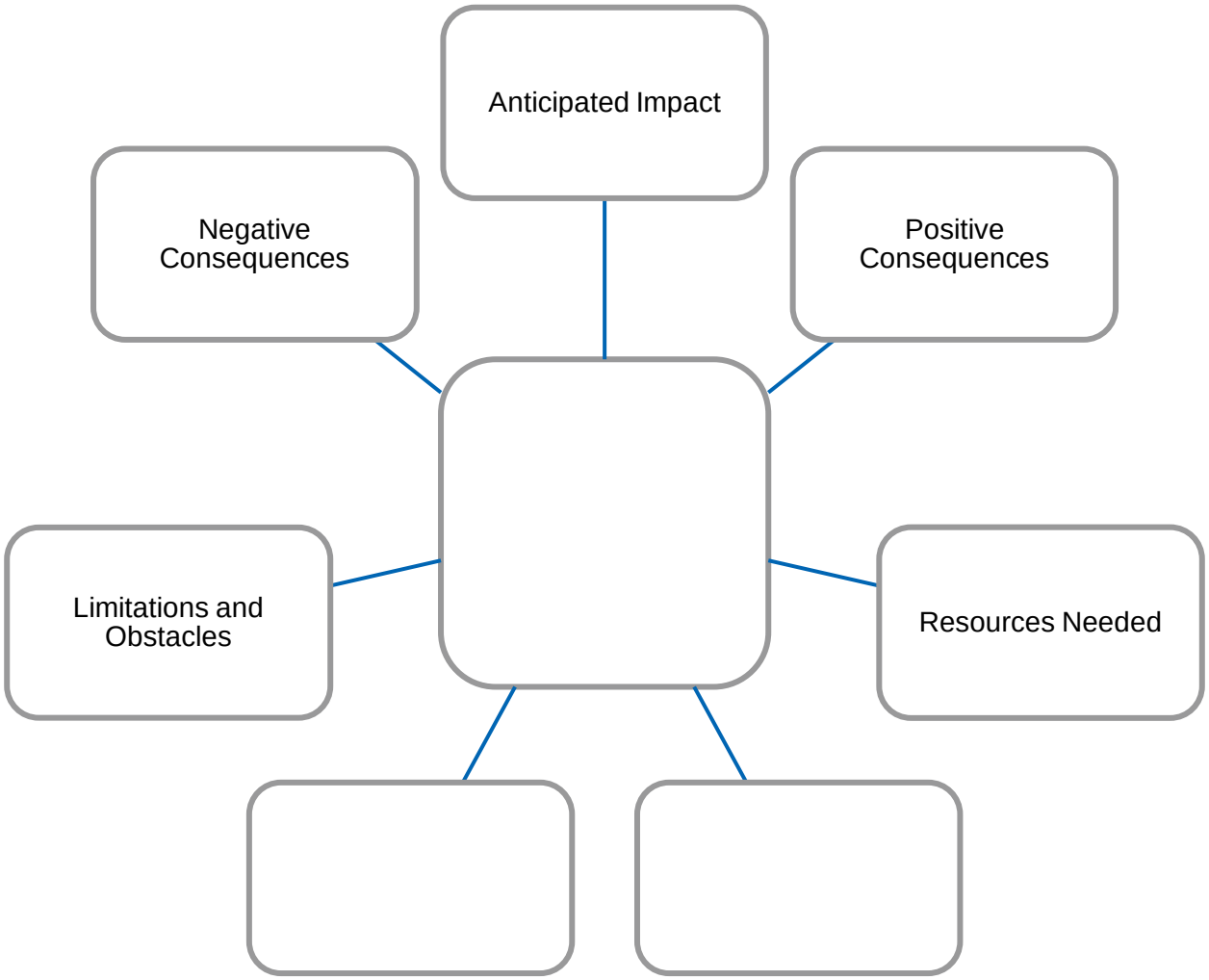
- Which idea would have an **observable** impact on your robot or team performance?
- Which idea would have a **valuable** impact on your robot or team performance?

Choose **one** of these ideas. How would you make the improvement?

Draw your idea, write your idea, or copy and paste images or links of solutions you've seen and would like to try.

How might the improvement impact your robot or team performance?

Choose one of the mapping templates or create your own to brainstorm the possible impact of the improvement, as well as any obstacles, limitations, or consequences that you might encounter.


Anticipated Impact
Negative Consequences
Positive Consequences
Limitations and Obstacles
Resources Needed

Performance Impact

Unit 6: Reflection and Improvement

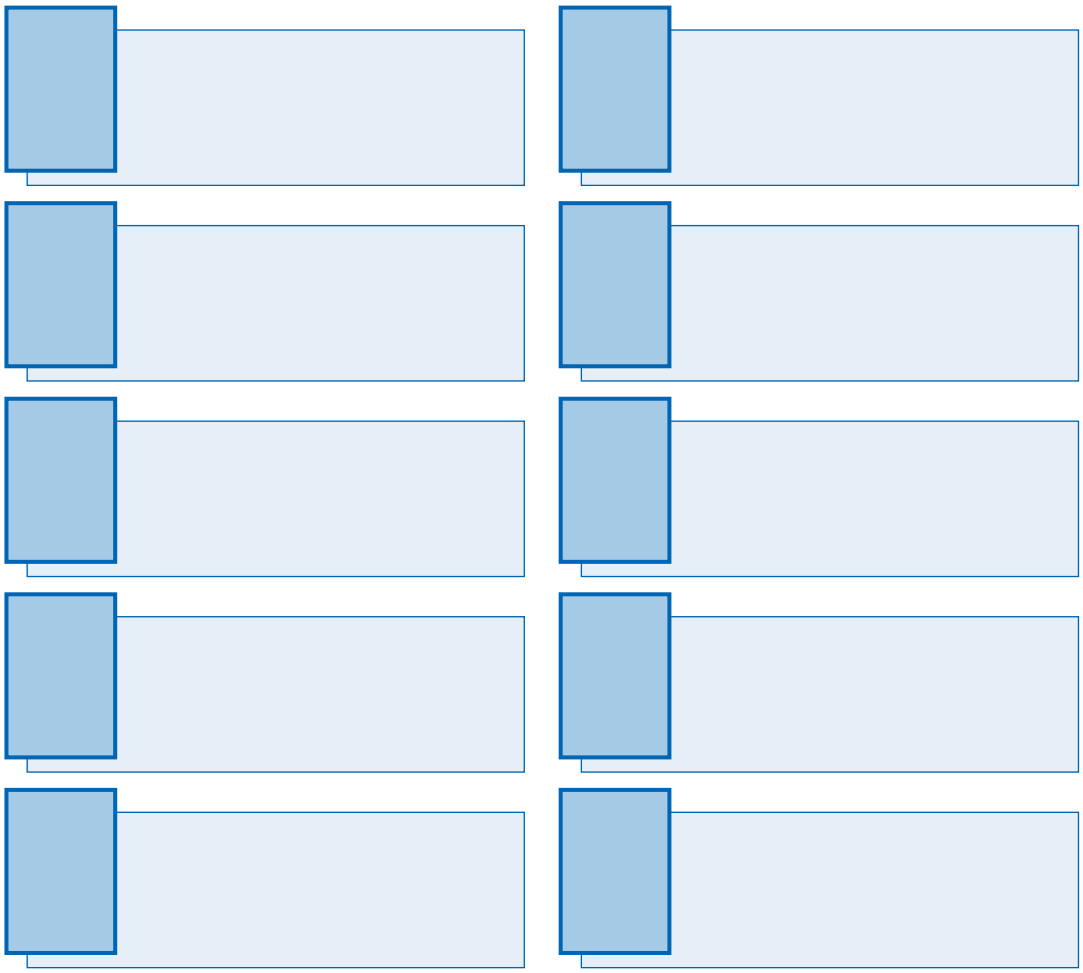
Impact Criteria Checklist:

Unexpected impact on performance:

Performance Impact

Unit 6: Reflection and Improvement

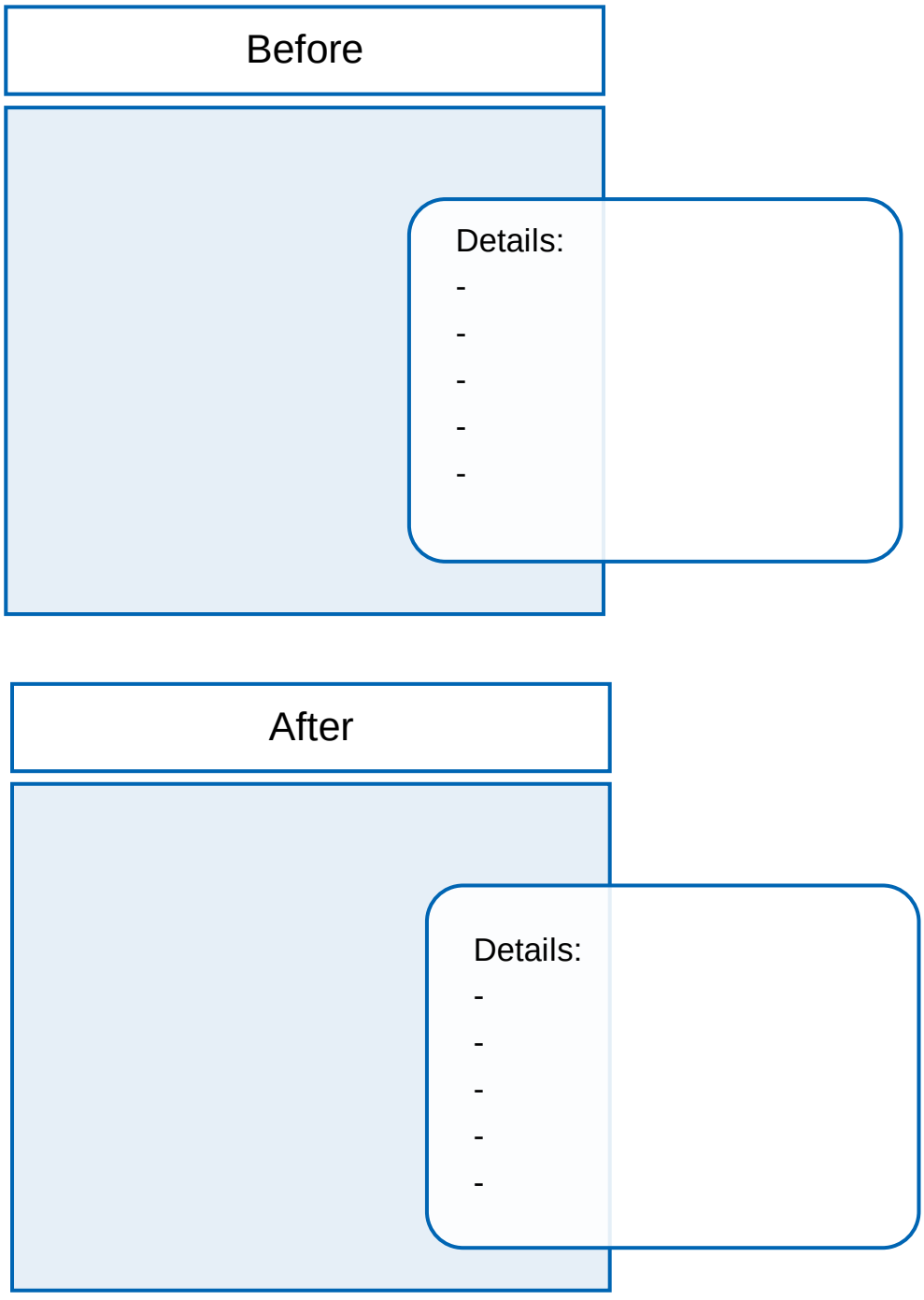
Impact Criteria Checklist:



Unexpected impact on performance:

Before and After Impact Summary

Unit 6: Reflection and Improvement

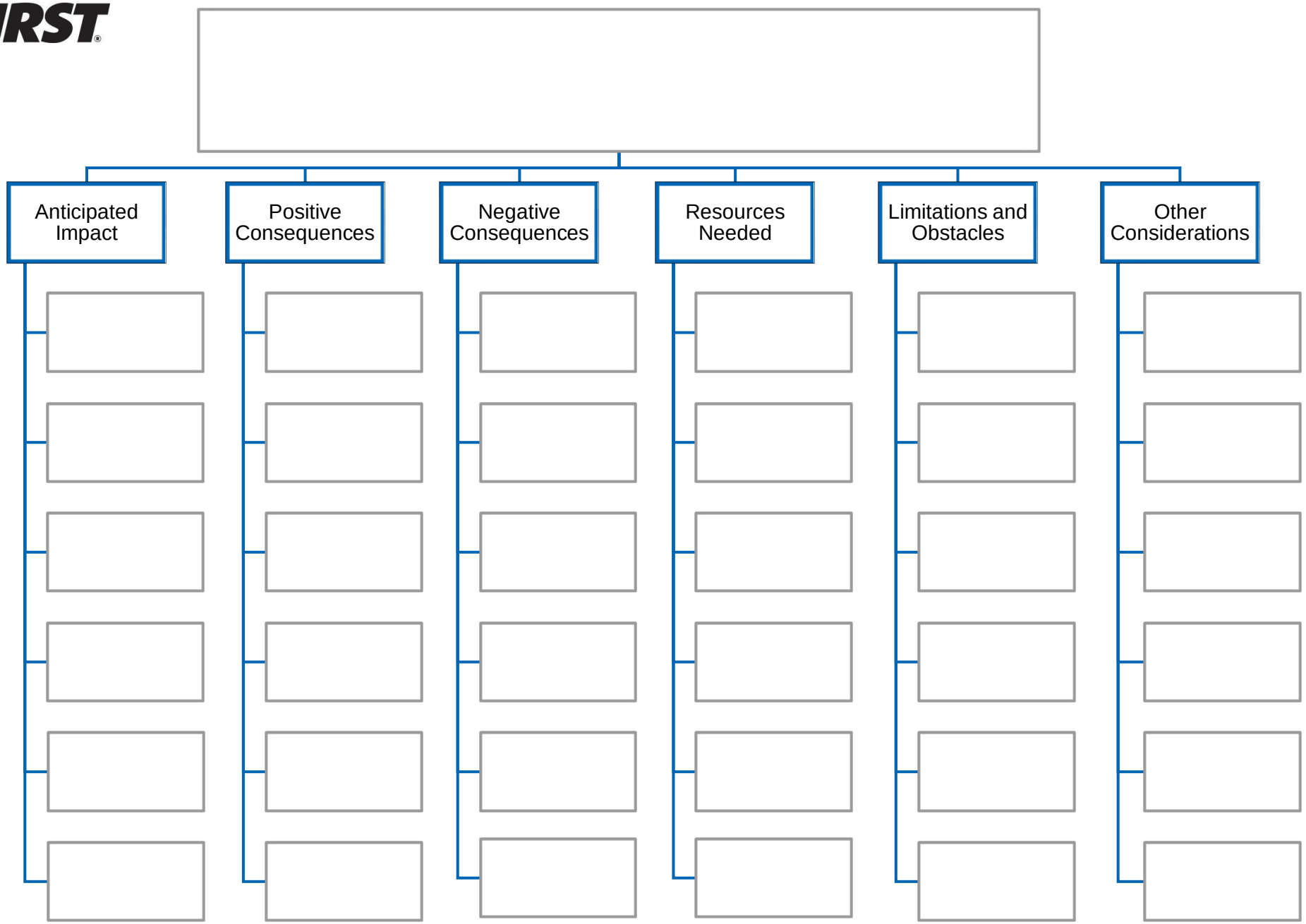


Before and After Impact Summary

Unit 6: Reflection and Improvement

Before	After
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•
•	•

Lessons learned:


Anticipated Impact
Positive Consequences
Negative Consequences
Resources Needed
Limitations and Obstacles
Other Considerations

Make a Decision - Rubric

Unit 6: Reflection and Improvement

	Emerging	Developing	Proficient	Advanced
Investigates and analyzes existing robot design and team performance for areas of strength.	Provides limited or superficial ideas about areas of strength.	Provides limited but evidence-based ideas about areas of strength.	Provides several evidence-based ideas about areas of strength.	Provides several evidence-based, insightful ideas about areas of strength.
Investigates and analyzes existing robot design and team performance for areas of improvement.	Provides limited or superficial ideas about areas of improvement.	Provides limited but evidence-based ideas about areas of improvement.	Provides several evidence-based ideas about areas of improvement.	Provides several evidence-based, insightful ideas about areas of improvement.
Analyzes how parts of a whole interact with each other to produce overall outcomes in a complex, collaborative system.	Demonstrates limited or no appreciation of the relationship between the parts of the robot or team.	Demonstrates a superficial appreciation of the relationship between the parts of the robot or team.	Demonstrates a clear appreciation of the relationship between the parts of the robot or team.	Demonstrates an in-depth and insightful appreciation of the relationship between the parts of the robot or team.
Considers constraints, consequences, costs and benefits of adopting new ideas.	Identifies up to three constraints but does not comment on how they will affect the adoption of new ideas.	Identifies up to three constraints and provides broad, general comments on how they will affect the adoption of new ideas.	Identifies more than three constraints and provides specific examples of how they will affect the adoption of new ideas.	Identifies more than three constraints, provides specific examples of how they will affect the adoption of new ideas, and proposes realistic solutions to the described constraints.

Make a Plan - Rubric

Unit 6: Reflection and Improvement

	Emerging	Developing	Proficient	Advanced
Effectively identifies tasks and subtasks required to complete an objective.	Identifies general tasks required to complete an objective.	Identifies specific tasks required to complete an objective.	Identifies specific tasks and subtasks required to complete an objective and demonstrates an effort to communicate the relationship between them.	Identifies specific tasks and subtasks required to complete an objective and effectively communicates the relationship between them.
Identifies resources to help complete an objective and evaluates their use.	Identifies up to three available resources but does not comment on their value or use.	Identifies up to three available resources and comments on how they will be used.	Identifies three or more available resources and comments on how they will be used to achieve specific objectives.	Identifies three or more available resources and comments on how they will be used to achieve specific objectives. Identifies alternatives where resources are limited or ineffective.
Prioritizes tasks and subtasks and manages work flow to achieve an objective.	Demonstrates an effort to prioritize tasks or estimate completion time to achieve an objective.	Prioritizes some tasks effectively and provides an estimate of completion time for some of them.	Prioritizes most tasks effectively and provides an estimate of completion time for all of them.	Prioritizes tasks effectively and provides substantiated estimates of completion time.

Performance Impact - Rubric

Unit 6: Reflection and Improvement

	Emerging	Developing	Proficient	Advanced
References relevant evidence when assessing the impact of the improvement.	Assesses the impact of the improvement with limited reference to criteria for evaluation.	Assesses the impact of the improvement and refers to some specific criteria for evaluation.	Assesses the impact of the improvement and refers to specific, relevant criteria for evaluation.	Assesses the impact of the improvement, refers to specific, relevant criteria for evaluation, and notes potential areas for further investigation or testing.
Compares the outcome of results with initial expectations.	Provides information about the outcome of results and initial expectations.	Provides some detailed information about the outcome of results and initial expectations.	Provides detailed information about the outcome of results and illustrates their relationship to or difference from initial expectations.	Provides detailed information about the outcome of results, illustrates their relationship to or difference from initial expectations, and describes why they may or may not align.
Draws conclusions about their improvement experience.	Inferences drawn from results are limited or superficial.	Inferences drawn from results are supported with evidence.	Inferences drawn from results are supported with evidence and include lessons learned from the experience.	Inferences drawn from results are supported with evidence, include lessons learned, and how they will be applied in the future.

UNIT 7

Skill Building

UNIT OVERVIEW

UNIT NUMBER: 7

DURATION: Up to 20 in-class hours depending on mini-challenge selection and adaptations for interest or experience level

SUMMARY

This unit will focus on the development of one or two new or interesting skills for individual students or groups within a team. The process defined will guide individuals or small groups of individuals with similar goals, in the selection of a key skill area for development. Students will select one or more mini-challenge scenarios to be completed or adapted as an independent project (with support from team/classmates, teachers/mentors, and *FIRST*-vetted resources), and then present evidence of their new skill development to classmates in peer-to-peer presentations or a small group mentoring session.

INSTRUCTIONS

1. As a class, speak in general terms about the value of setting goals for personal development.
2. Provide students with the Individual Engineering Notebook. Have them complete the Personal Goals section to help them identify an area of skill development that they would like to explore.
3. Divide students into pairs or small groups and have them discuss their goals for personal development with their partner or group. Encourage students to provide each other with constructive input and ideas about their goals and how they can accomplish them. (e.g., resources, ideas, tools, etc.)
4. Review the mini-challenge scenarios with students and have them select one or more mini-challenges to complete or adapt to suit their personal goals or current level of ability. Students may work together in small groups or work to complete their challenge individually. Let students know that this unit will end with a peer-to-peer presentation to demonstrate the experience and skills they have gained.

LEARNING RESOURCES

***FIRST* Tech Challenge Self-Reflection and Planning Resources**

- Individual Engineering Notebook
- Skill Development Reflection

Programming Resources

- Java4Robotics curriculum

CAD Resources

- PTC for FIRST Teams

5. Provide students with time to complete their challenge. Encourage them to assist each other where possible, and to document their experience, as well as effective resources they've used throughout the process. This is similar to what they would do during the competition season in their Engineering Notebook.
6. Have students assemble evidence of their skill development in the Demonstrate your Experience section of the Individual Engineering Notebook. They will use this to share their learning with classmates in peer-to-peer presentations. Presentations can be completed informally in small groups with similar interests, or more formally to the class.

- 3D Printing for FIRST Teams Blog Series by PTC

ASSESSMENTS:

1. Weekly Engineering Notebook
2. Weekly Self & Peer Evaluation
3. Individual Engineering Notebook
4. Skill Development Reflection
5. Skill Development Checklist
6. Mini-Challenge Scenarios

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Programming Software (based on availability and interest)
3. CAD Software (based on availability and interest)
4. Graphic Design Software (based on availability and interest)
5. Collaboration Software (based on availability and interest)

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

PERSONAL GOALS

The mission of *FIRST* is to inspire young people to be science and technology leaders and well-rounded contributors to society. While the *FIRST* Tech Challenge itself is a team-oriented competition, the personal growth and development of individual students and their skill sets both within and around the STEM field are integral to the experience. Students gain valuable life and work skills they can take beyond the competition or classroom.

As a class, talk about the value of goal setting in terms of personal development. As a warm up activity, it may be a good idea to have students share a goal they have set and achieved in the past. Students can draw from experiences outside the context of *FIRST* or the classroom (e.g., learning to change a tire, getting a driving permit, making a new friend, baking a cake, earning enough money at a part-time job to buy a laptop).

After speaking generally about personal goals, have students consider their experience with the *FIRST* Tech Challenge.

Divide students into small groups and provide them with the Individual Engineering Notebook resource.

The Individual Engineering Notebook is a **personal** resource to help students identify and document their own goals, ideas, progress and achievements, just as the Engineering Notebook for the *FIRST* Tech challenge chronicles the process of problem solving, engineering design, and **team** development. The goal of the Individual Engineering notebook is to guide students through a process of self-assessment and practical goal setting. The process results in documented evidence of skill development in engineering and related fields, that can be demonstrated to peers, parents, teachers, on post-secondary applications, or to potential employers.

Have them complete the section on PERSONAL GOALS individually and then share their ideas with a neighbor.

Guiding Questions:

1. What were some of the goals you had when you started the *FIRST* Tech Challenge?
2. How do you see those goals being useful to you in your social, academic, or professional lives?
3. Have you achieved any of those goals through your experience with the *FIRST* Tech Challenge? If so, which ones?
4. Are there any goals you had at the beginning of this experience that you have not yet achieved?
5. What roles, tasks, or responsibilities did you take on throughout the *FIRST* Tech Challenge?
6. Where there any roles, tasks, or responsibilities you would like to have tried, that you didn't have a chance to try?

HINT:
It may be a good idea to have students speak with classmates or team members who have been involved with roles that are different from their own, to discuss tasks, benefits, and challenges involved in taking on those responsibilities. These students may also prove valuable later in the activity, as resources to support individuals as they complete their selected challenges.

Personal Goals Facilitator's Tips:

Q: How can I encourage students to share their goals and ambitions?

A: It's important to set a tone and expectation of open-mindedness and inclusivity in the classroom. Teachers may wish to revisit the *FIRST* Values to encourage Gracious Professionalism® and Coopertition®.

Students should be reminded that an individual's goals and motivations may be surprising to you, but are deeply personal and fundamentally important to them. This unit presents an opportunity for students to branch out and take a supported risk. Assumptions or biases about what a person or group should or shouldn't be interested in can have a significant effect on student engagement.

You may also share a goal that you have worked on currently or in the past, and how you pursued it. What did you do? What went well? What didn't go well?

SELECT A CHALLENGE

After completing the Personal Goals section of the Individual Engineering Notebook, review the eight mini-challenge scenarios with the class.

The mini-challenge scenarios and Driving Questions can be provided to students from the Mini-Challenge Scenarios resource document. The resource also includes a template for students to map out initial and formative questions they will need to ask themselves and others to complete the objective of their mini-challenge.

While the mini-challenges have been developed as shorter, self-contained activities, teachers or students may wish to combine or integrate challenges, or have students work together to create more complex, interdisciplinary challenges.

Additional (Optional) Challenges have been provided in the instructor's notes for each mini-challenge to encourage adaptation and expansion of the activities to suit the individual needs of a student working independently, or to meet the integrated needs of a small group of students with complimentary goals.

Guiding Questions and Suggested Resources have also been included.

Select a Challenge Facilitator's Tips:

Q: How should the mini-challenges be introduced to students?

A: The mini-challenges can be introduced and discussed by the class together or students may review them in small groups of individuals with similar goals. In some situations, teachers may wish to discuss student goals individually and then offer suggestions about challenges or adaptations that may be suitable.
Regardless of how the mini-challenge scenarios are introduced, the selection of an area for skill development should be student-driven and connected to the goals students have outlined in the Personal Goals section of the Individual Engineering Notebook.

Q: How can I encourage students to try something new?

A: Some students may be interested in a different area of development, but hesitant to try something outside their comfort zone. Some students may become frustrated, intimidated, or feel as if they have failed if they cannot easily accomplish the objective they have set for themselves.
Students should be encouraged to adapt mini-challenges to suit their level and interest, but not to shy away from the "challenge" part. It's important, at this point in the process, to emphasize that valuable lessons can be learned from attempts that are less than successful. Setting realistic but challenging objectives is a skill, in itself, that has to be developed. It's ok to modify the objectives of the mini-challenge (before or during the challenge), or to isolate one component of it as a more manageable task for skill development.

Q: How can students be assessed when they are completing customized challenges?

A: Challenge scenarios are intended to be open-ended, student-directed, and adaptable. Assessment will be based on student self-evaluation and their ability to provide and explain evidence of their learning.

A Skill Development Checklist has been provided for teachers to document and track student progress through the process outlined in the Individual Engineering Notebook.

A Skill Development Reflection resource has also been provided for students to evaluate and think critically about their own experience with the challenge.

Q: How many mini-challenges should students complete?

A: The mini-challenges have been created as independent projects for completion, but may also be combined or completed one after the other if students have broader goals or more experience with the required skill set.

Suggestions have also been provided with each scenario to add additional challenge or complexity. Students should be encouraged to modify the challenge or increase its level of complexity to suit their needs and ambition.

Space has been provided to develop and make note of adaptations to the challenge, both in the Select a Challenge section of the Individual Engineering Notebook, and on the individual Mini-Challenge Scenarios document, where students can modify the Driving Question.

Teachers may wish to guide students in this process by suggesting an Additional (Optional) Challenge or by having students with complimentary goals work together to complete different aspects of an expanded challenge.

MAKE A PLAN AND COMPLETE THE CHALLENGE(S)

Think about the steps and resources needed to complete the challenge.

HINT:
In an open-ended challenge, expect that the tasks will change as the project evolves and students gain a better understanding of what is required to meet their objectives, or the time and resources available to them.

Use the template provided in the Individual Engineering Notebook, select one of the Make a Plan templates from Unit 6, or have students create their own timeline of tasks, resources, and learning that will need to take place to accomplish the challenge.

Have students complete the challenge they have selected or adapted, using the Make a Plan section as a living document to track, not just the tasks they are completing, but how they are adapting to the challenge and how they are adapting the challenge to their needs or goals.

As they learn and work to complete the challenge, they should gather evidence of their progress in the form of notes in the Individual Engineering Notebook, images, links to videos they have created and posted, or screen shots of programming progress. The Notes and Observations section of the Individual Engineering Notebook can be copy and pasted in word doc format, or reproduced in hard copy to document progress, observations, and notes as students complete each work session. There is also a section for Steps for Next Session to help students target and document priorities and prepare for the next work session.

It's important at this point, to also draw student attention to the Demonstrate your Experience section of the Individual Engineering Notebook.

Make sure that students understand that they will need to provide evidence of their skills (even if they are different from their original goals) in the final step of this unit, where they will share their learning with classmates.

Make a Plan Facilitator's Tips:

Q: How can the Make a Plan section in the Individual Engineering Notebook be used?

A: The Make a Plan section is intended to function as a living document, where students can identify tasks and subtasks and create a general timeline to complete them. Additional steps may be added or steps may be removed as students work to complete their challenge, or modify it to better suit their level or timeframe.

Changes can be documented in the Notes section, or the whole Make a Plan section of the document may be copied and pasted repeatedly with version numbers to show how the plan evolves as the student starts to think more critically about which tasks really matter and which tasks may not be as relevant as they had initially planned.

Students should be encouraged to adapt the section to their needs and documentation style. This is an area to work through the steps and track valuable resources or developments. Teachers can periodically review this section with students as a formative assessment to identify challenges or areas where they may need more direction.

DEMONSTRATE YOUR EXPERIENCE

Have students complete the Demonstrate your Experience section of the Individual Engineering Notebook.

The desired outcome is a list of proven skills gained by completing the challenge(s) they selected or adapted.

Students can use this evidence for the creation of academic or professional portfolios, with skills described and presented as they would in a judging session for the *FIRST* Tech Challenge, on an application for post-secondary education, or as they would be included for employment on a CV or in a job interview.

For this presentation, divide students into small groups to share the skill(s) they have developed.

Encourage students to assume the role of a mentor, who is sharing their experience and examples of their expertise. Partners or other students in the group may be provided with suggested questions to ask the student who is presenting as a mentor, or prompted to take 5 minutes after the "mentor" has presented to think of their own to generate discussion.

Students should approach these peer-to-peer sessions with an eye, not just for the efforts of their classmates, but for new ideas and areas of skill development they might like to investigate in the future.

Sample Questions for Students to ask Each Other:

- Why did you choose to develop this skill?
- Tell me about the problem you had to solve for this challenge.
- Tell me about how you worked through the problem.
- What resources did you use to learn about this?
- What obstacles did you face while completing this challenge?
- Tell me about how you overcame these challenges.
- What skills have you developed through this experience?
- Show me examples of your work or ability in this area.
- Tell me about your future goals or next steps in this area.

Demonstrate your Experience Facilitator's Tips:

Q: How should groups be determined for the peer-to-peer presentations?

A: Students may find it worthwhile to discuss their learning experience and to share ideas and solutions with a few other students who share their interests or some of their personal goals. This may, however, prove difficult to organize in small classes or in classes where individuals have very different personal goals from their peers.

Creating mixed groups of individuals with diverse interests or experience can be a good way to promote communication across team members and fields of interest. Sometimes, truly inspiring ideas and solutions come from fresh eyes and an open mind. Students with different interests or goals may view things from a unique perspective or ask questions that might not occur to someone who is already skilled in that area.

Q: How can we ensure that feedback is critical but respectfully given?

A: Before peer-to-peer presentations begin, it may be a good idea to review the "Critical Friends Protocol" from Unit 4. This process may already be familiar to students, but reviewing it briefly can also act as a friendly reminder, not just about the process, but about some of the language that can be used when questioning and collaborating with peers.

Skill Development Reflection

Unit 7: Skill Development

Name: Date:

In your own words, describe the challenge you completed.

Note: The challenge you completed may differ from the challenge you originally planned to complete.

Select the phrase below that best describes how close you have come to achieving the personal goal(s) you set for yourself at the beginning of this unit.

Provide more details in the “Comments” section.

I did not work towards my goal.	I made some progress toward achieving my goal(s).	I achieved one or more of my goal(s).	I exceeded my goal(s).
Comments:			

Identify and comment on at least three skills you feel you have developed through this experience.

Skill Description:	

Skill level when you started the challenge:	Beginner	Intermediate	Advanced	Expert
Description of how the skill was developed:				
Skill level when you completed the challenge:	Beginner	Intermediate	Advanced	Expert
Comments:				

Skill Description:				
Skill level when you started the challenge:	Beginner	Intermediate	Advanced	Expert
Description of how the skill was developed:				
Skill level when you completed the challenge:	Beginner	Intermediate	Advanced	Expert
Comments:				

Skill Description:				
Skill level when you started the challenge:	Beginner	Intermediate	Advanced	Expert
Description of how the skill was developed:				
Skill level when you completed the challenge:	Beginner	Intermediate	Advanced	Expert
Comments:				

Problem Solving and Communication Scenario

Unit 7: Skill Development

SCENARIO:

Imagine that you are an engineer collaborating with another engineer in a completely different location. You are in Location A and your partner is in a remote location (Location B), out of sight, and out of range for direct verbal communication.

You have been asked to design a simple model made from the Tetrix Kit of Parts, Matrix Kit of Parts, or another set of pre-determined components provided by your teacher.

You will be designing the model at your location (Location A), but the final product will need to be reproduced by your colleague at a different location (Location B).

Your colleague, located in Room B, has the required components, but does not have the design specifications for the model. They will need recreate the model you've designed, based on communication from you, the individual in Room A.

- What will you need to consider when designing your model?
- What will you need to consider when communicating how to build it?

Note: You may not take a picture of the design or show the individual (in Location B) a photo of the model you have developed.

DRIVING QUESTION:

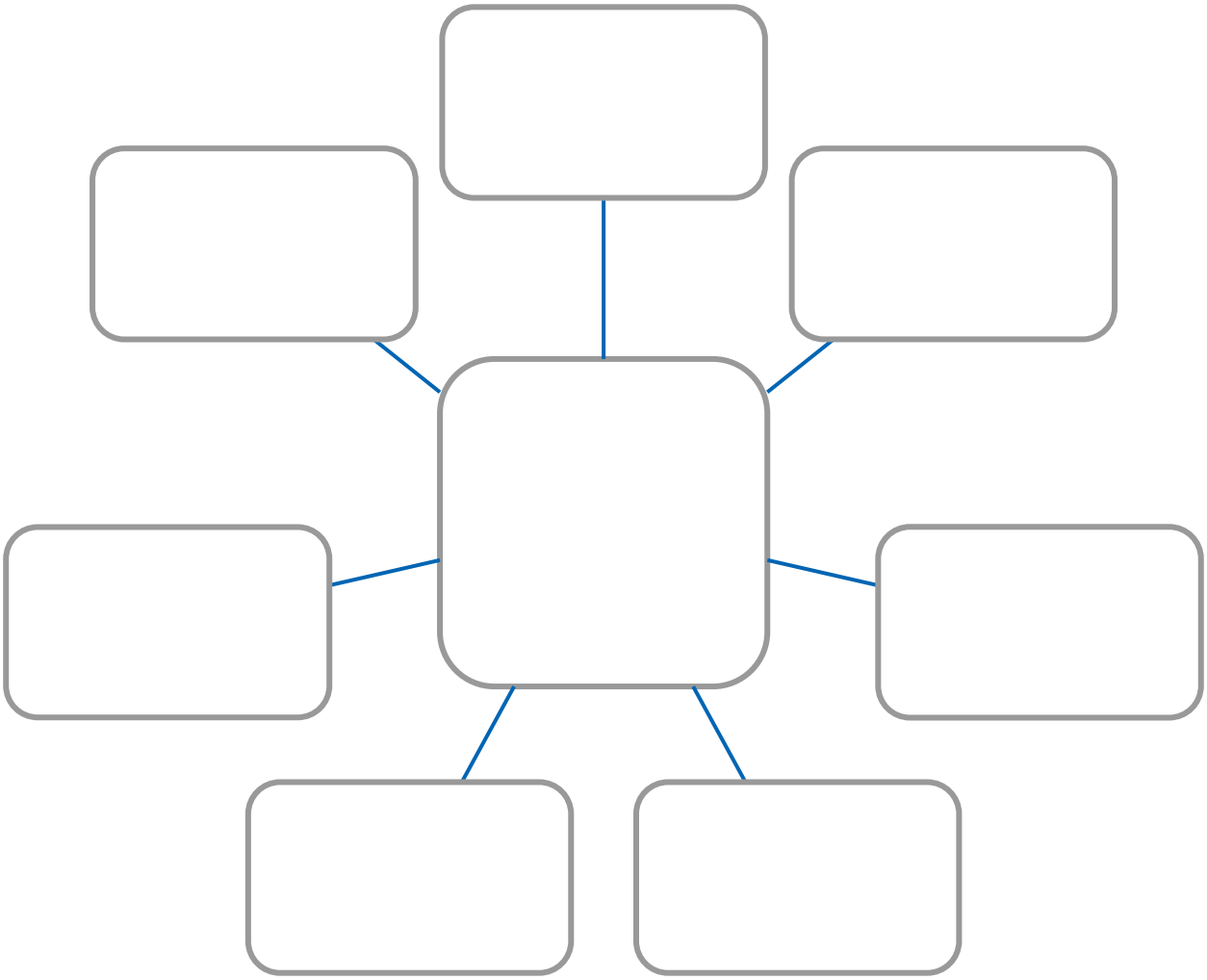
	How can available resources and components be used to design an original model in one location and to have someone build it in another location?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



CAD Design Basics Scenario

Unit 7: Reflection and Improvement

SCENARIO:

You have entered a competition where the playing field is flat, but there are some fixed obstacles that cannot be easily avoided by driving around them.

Since you can't go around them, and you can't go under them, your team has decided that the best approach is to try to pass clearly over them.

To accomplish this objective, you need to raise the chassis on the existing robot and increase the clearance between the playing field and the robot so it doesn't get caught on the obstacles as it passes over them.

The new chassis needs to be 20% further from the ground than your current competition robot.

To have your team build the new chassis, you will need a detailed design that includes:

- A detailed visual model of the chassis, including labelled dimensions
- A precise list of resources and materials you need that are currently available to you (e.g., kits of parts, classroom resources, 3D printed or manufactured materials)
- A precise list of any components you need to borrow, buy, or make if they are not currently available for you to use
- A completed CAD model that shows how the components fit together and to confirm that they meet the necessary requirements for size and clearance

DRIVING QUESTION:

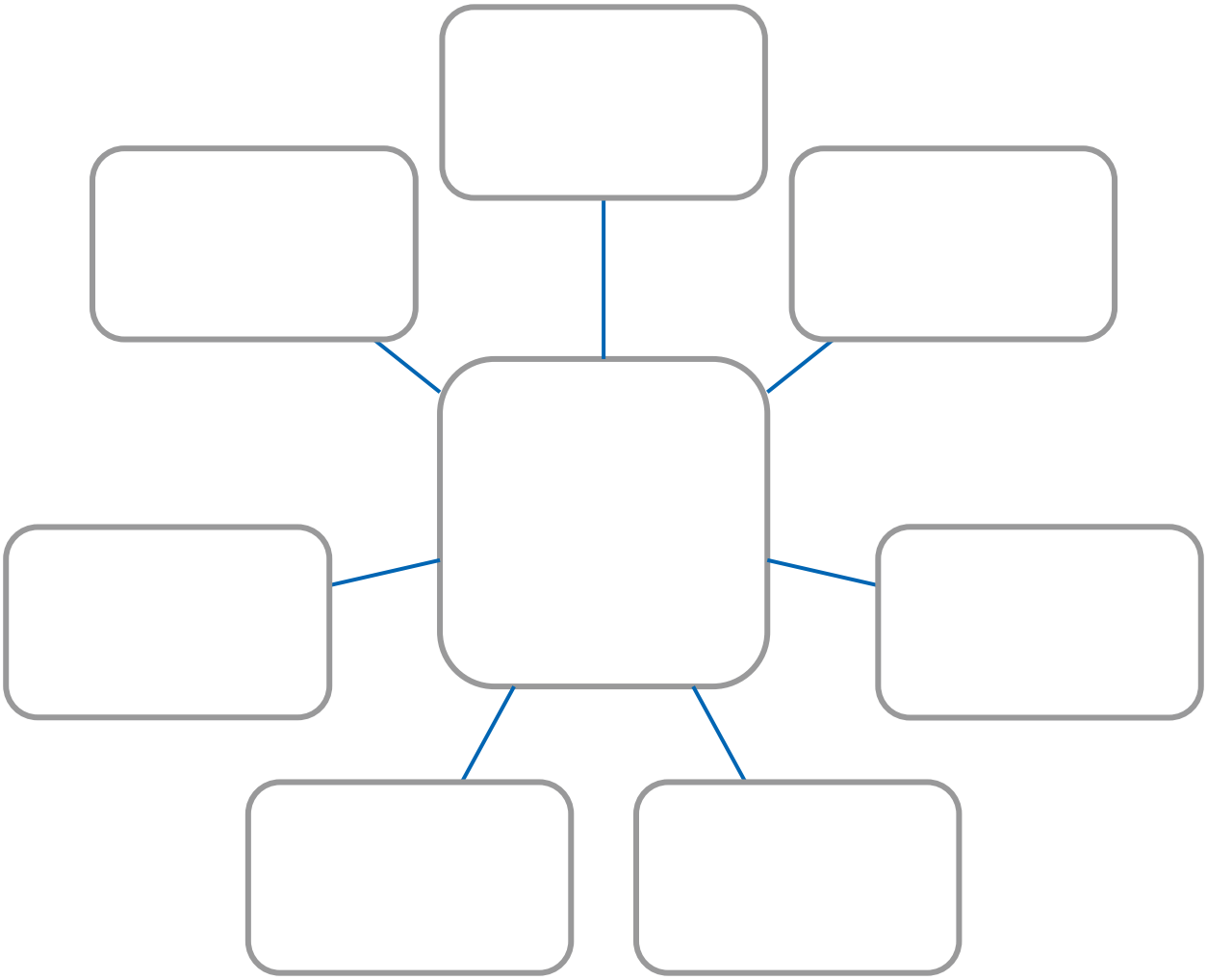
	How can you use CAD software to design a new chassis with a 20% greater clearance from the ground?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



CAD Design Advanced Scenario

Unit 7: Skill Development

SCENARIO:

You need to design a new gripping end effector for your robot, but will not have access to your team's physical robot or components to do so.

You have access to a CAD model of the robot (if already created) and some CAD files of components, as well as whatever you can make.

The end effector will need to articulate or swivel to pick up a small, spherical object located 24 inches away from the robot, on a platform that is elevated 12 inches off the ground.

You need to use CAD software to confirm that the gripping end effector will swivel along the axes defined and reach the object in question.

You will also need to provide your team with:

- A detailed visual model of the end effector, including labelled dimensions
- A precise list of resources and materials that are currently available to you (e.g., kits of parts, classroom resources, 3D printed or manufactured materials)
- A precise list of any components you need to borrow, buy, or make if they are not currently available for you to use
- A completed CAD model that shows how the components fit together and to confirm that they meet the necessary requirements for size and functionality

DRIVING QUESTION:

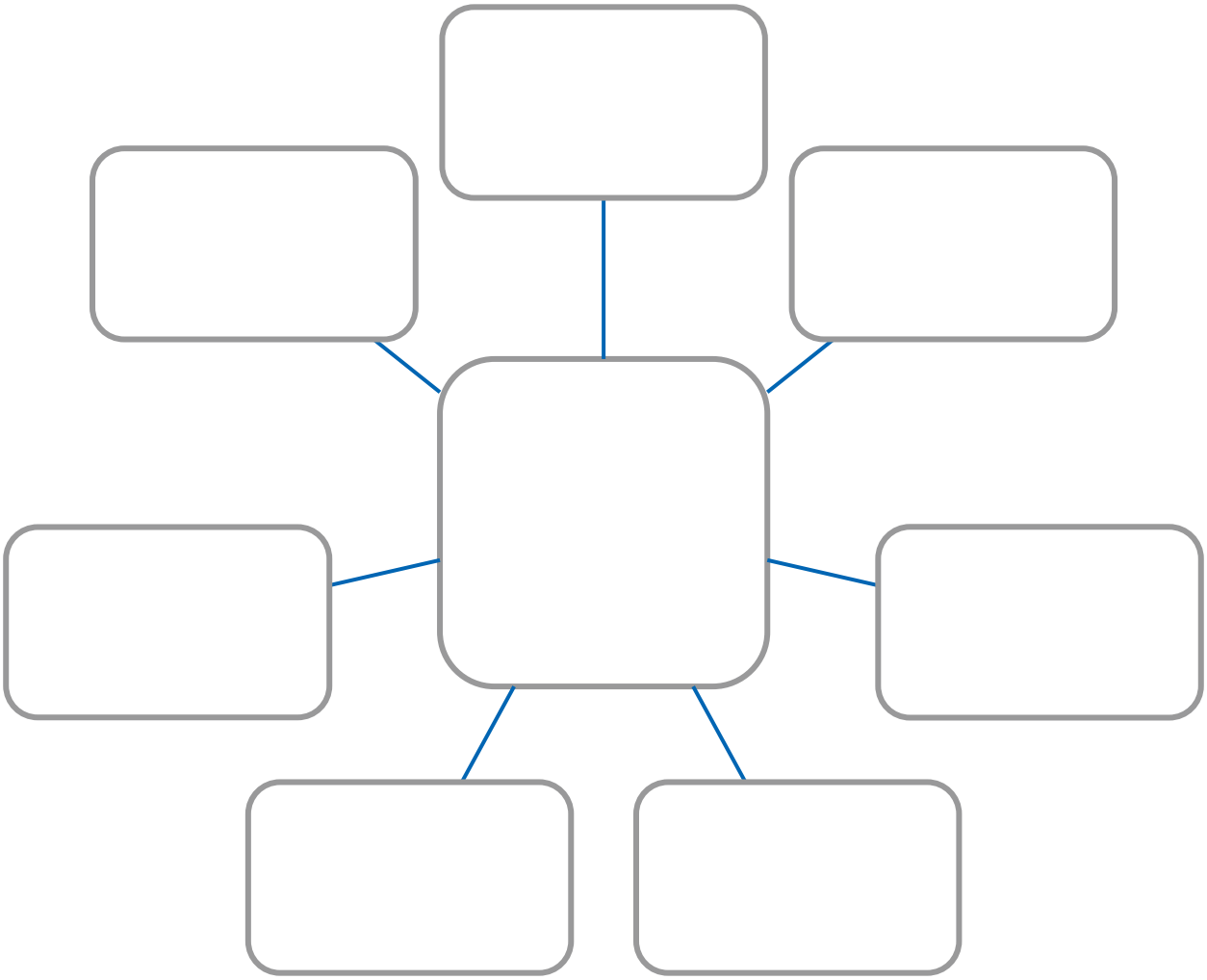
	How can you use CAD software to design and confirm the functionality of a new gripping end effector?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Programming Basics Scenario

Unit 7: Skill Development

SCENARIO:

You are looking forward to working with the Pushbot (or your own robot) and don't want to waste a minute of class time when you arrive at your work station.

You need to program the robot to wait on standby for your arrival, and to respond to a "Let's get started!" command with an enthusiastic display.

Challenge Criteria:

- Use the Pushbot or a robot of your own design to complete this challenge.
- You may use a Reflected Light sensor, an Analog Touch sensor, or another sensor of your choosing to gather data.
- Program the robot to use data from one sensor to exist in a "sleep" mode and "wait" for your arrival. The robot should use sensor data to tell it when to sleep and when to "Wake up!"
- The robot should "Wake up!" if a user is detected approaching the work station and prepare for action.
- Once the robot is "awake," the robot should respond to data from a second sensor to "Get Started" with an interesting display (e.g., text, sound, movement pattern).

DRIVING QUESTION:

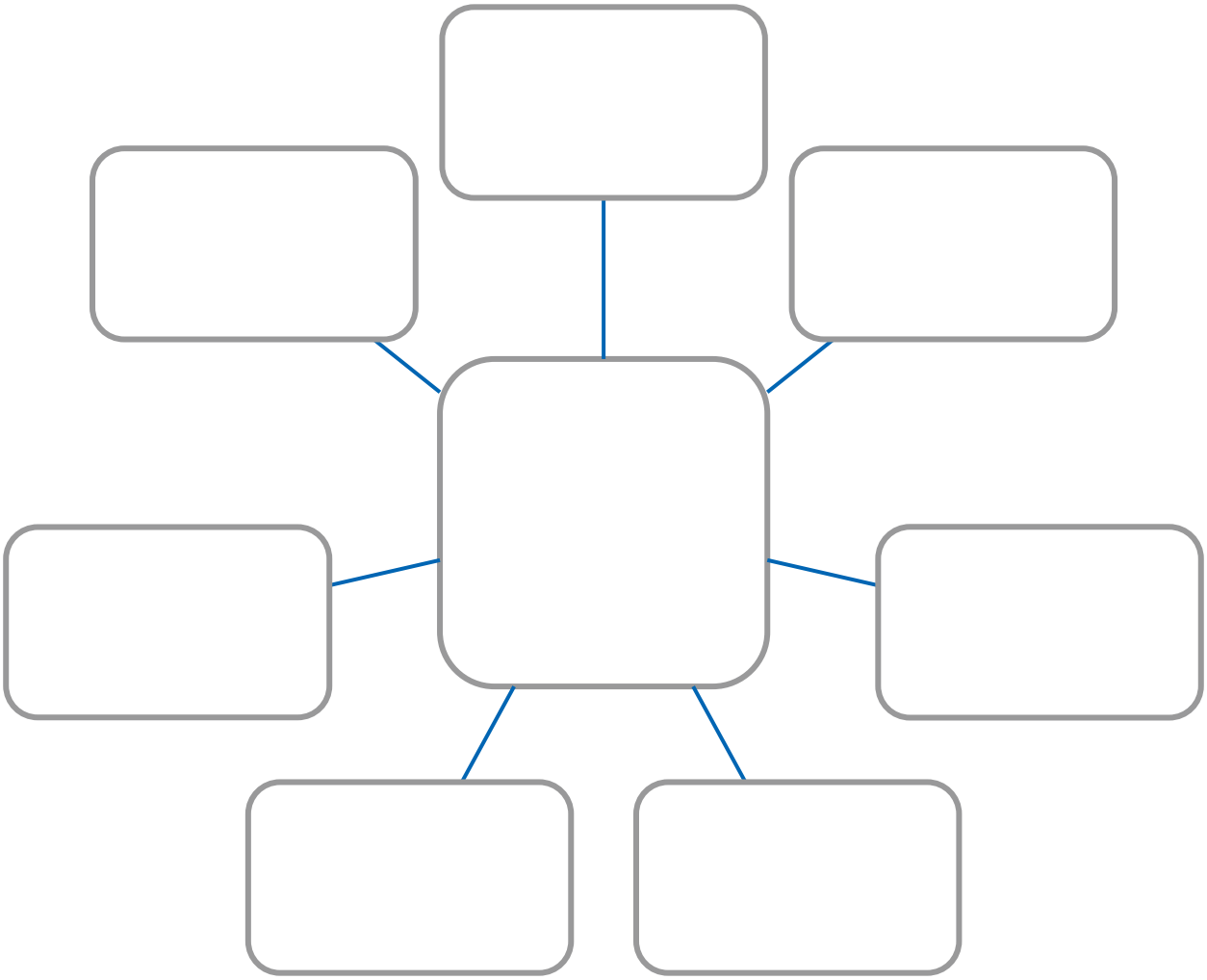
	How can you use Java or MIT App Inventor to automate the activation of a robot from a sleep mode, to standby, to an active state?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Programming Advanced Scenario

Unit 7: Skill Development

SCENARIO:

You have been asked to create a text-based game for a classmate to play.

Your classmate has asked for a game of Tic Tac Toe, or similar game of your own design.

You may need to define:

- The goal of the game.
- How the game will be played.
- Who will play the game? (E.g., two players or one player against the computer)
- The positions of game squares.
- The “winning” state for the game.

What will your game look like and how will it work?

DRIVING QUESTION:

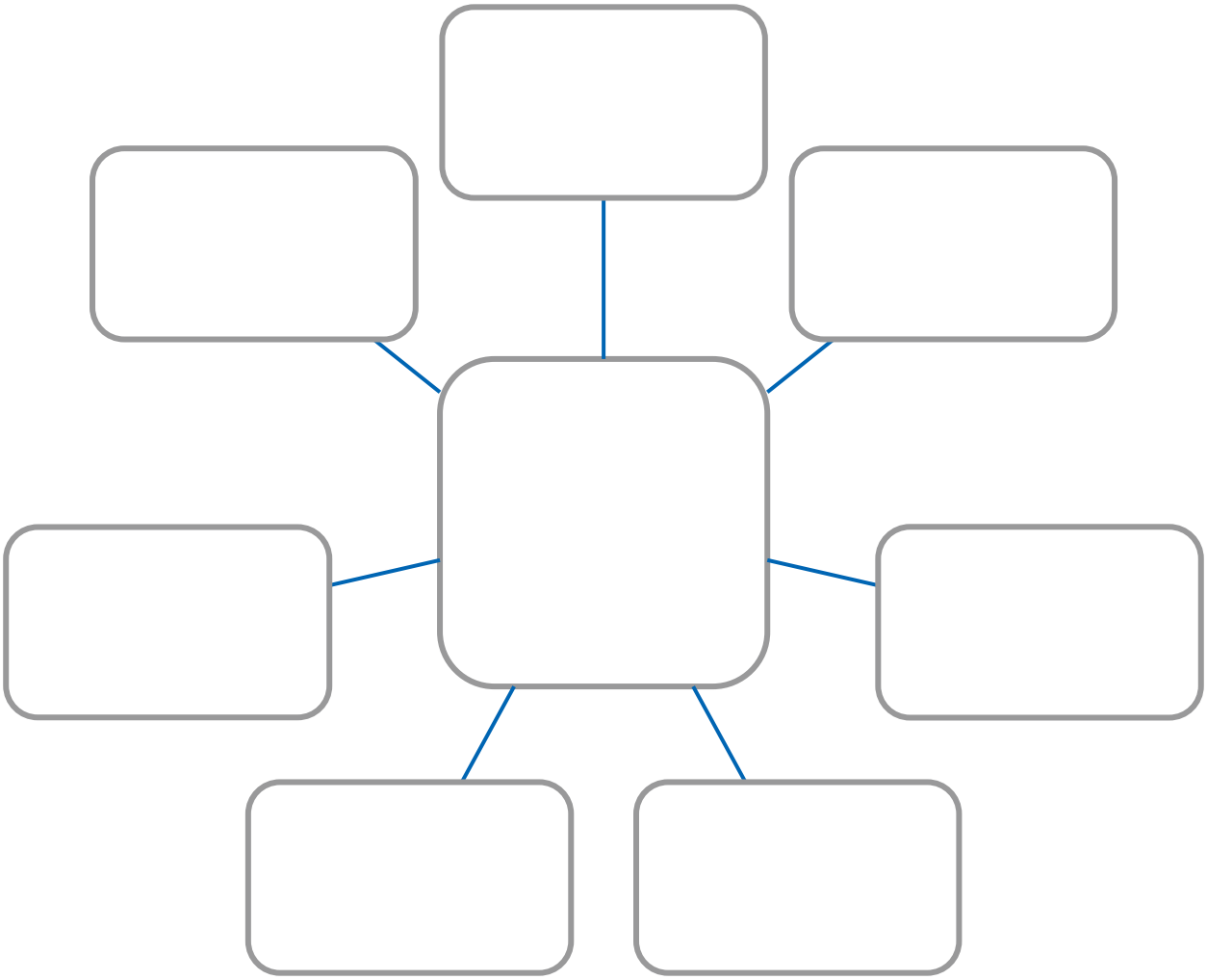
	How can you use Java or MIT App Inventor to create a playable, text-based game?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Programming Basic Path Scenario

Unit 7: Skill Development

SCENARIO:

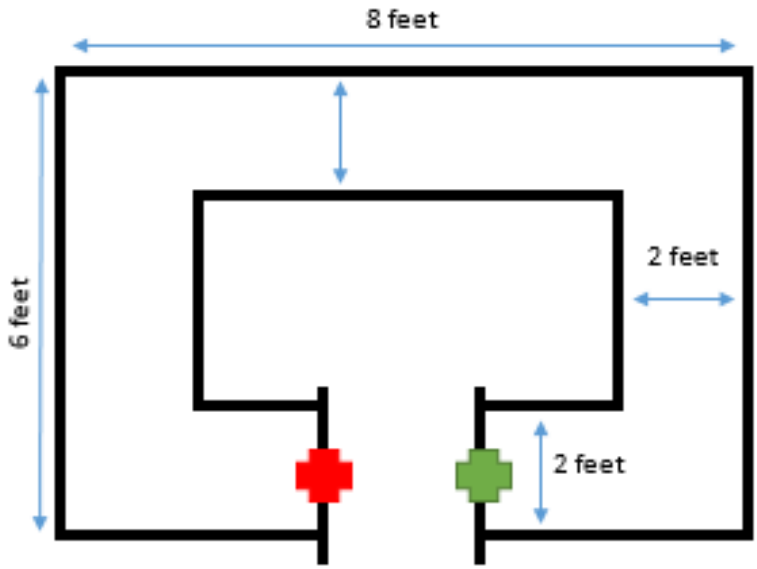
Your team has been challenged to program a robot to navigate along a defined path that has been taped to the floor. Your robot must accomplish this task without a driver to control it.

Your robot should:

- Stay within the confines of the tape.
- Not be controlled by a driver.

Sample Basic Path Configuration:

- The tape should be black and at least 1 inch in width.
- Working on a light-colored surface should produce better results.



DRIVING QUESTION:

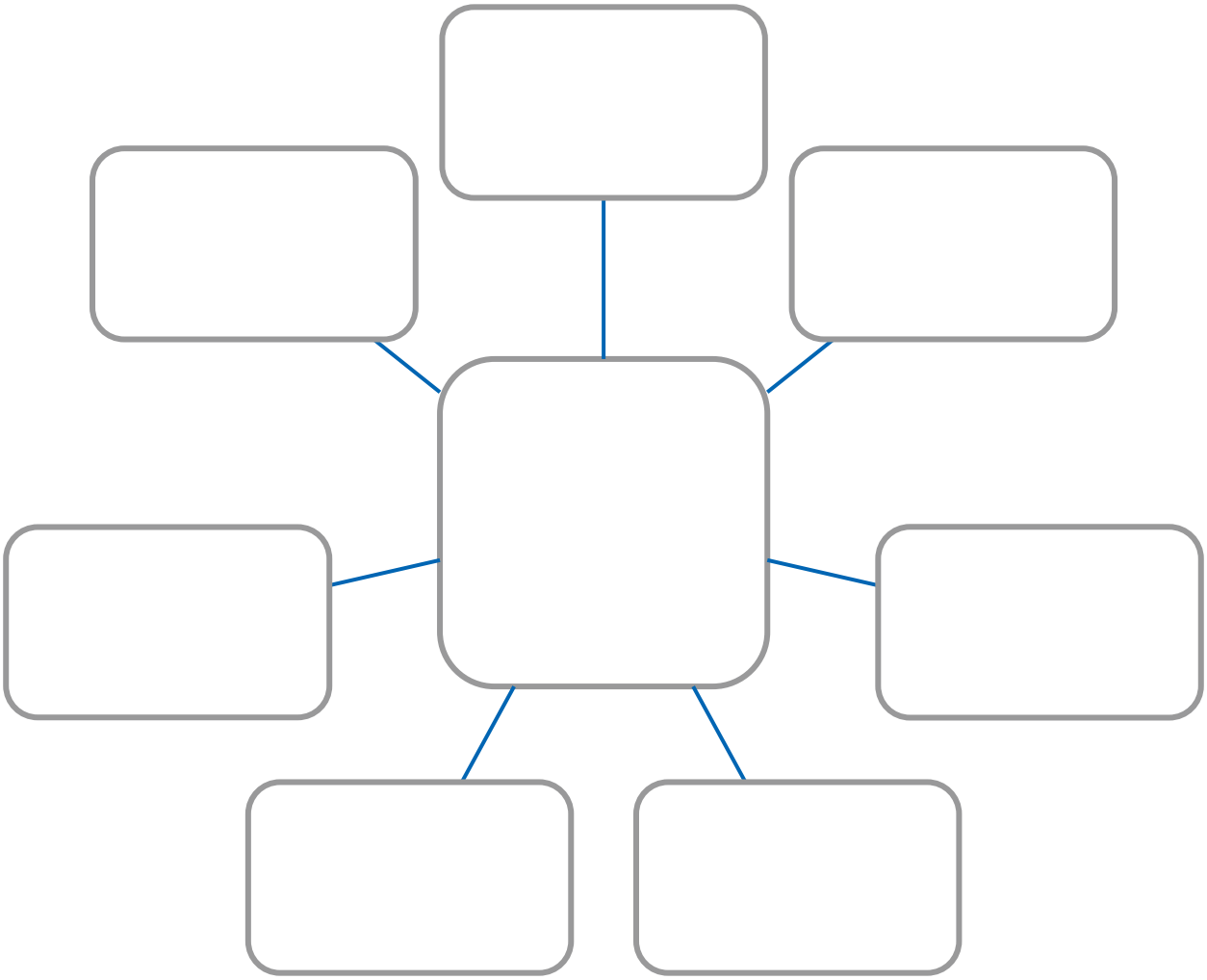
	How can we program a robot to navigate a defined path, without being controlled by a driver?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Programming Advanced Path Scenario

Unit 7: Skill Development

SCENARIO:

After completing the Programming Path Challenge, your team has been asked to program a robot that can navigate not just a particular path, but **any** path.

The path your robot must follow will be taped to the floor.

Your robot will need to navigate the path in one direction, and then turn around and complete the same path in the opposite direction, without a driver to control it.

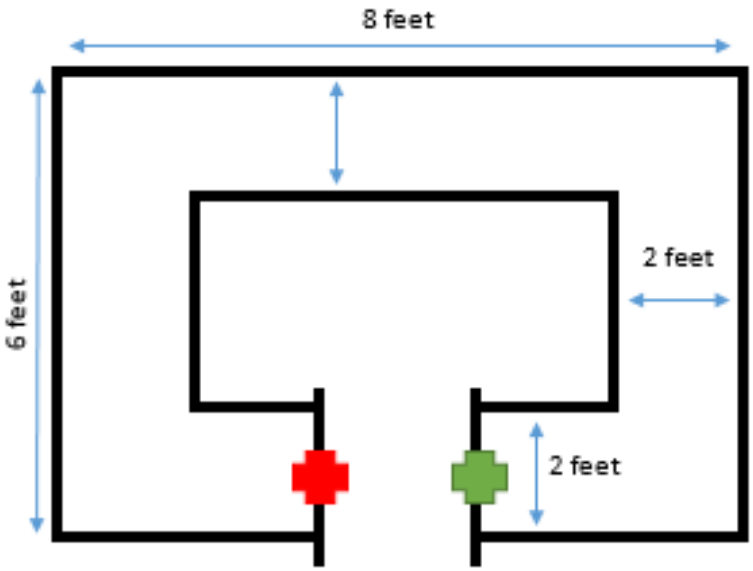
It should also be able to complete a second, different path configuration in the same way.

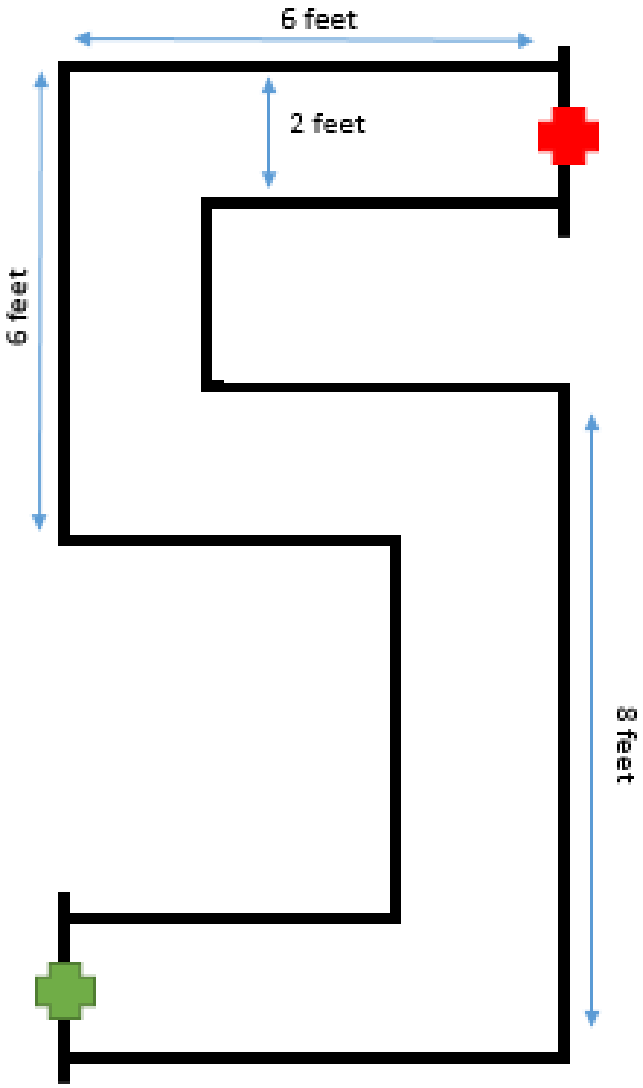
Your robot should:

- Stay within the confines of the tape.
- Not be controlled by a driver.
- Be able to follow the path (or any marked path), in both directions, with **one** program.

Sample Advanced Path Configurations:

- The tape should be black and at least 1 inch in width.
- Working on a light-colored surface should produce better results.





DRIVING QUESTION:

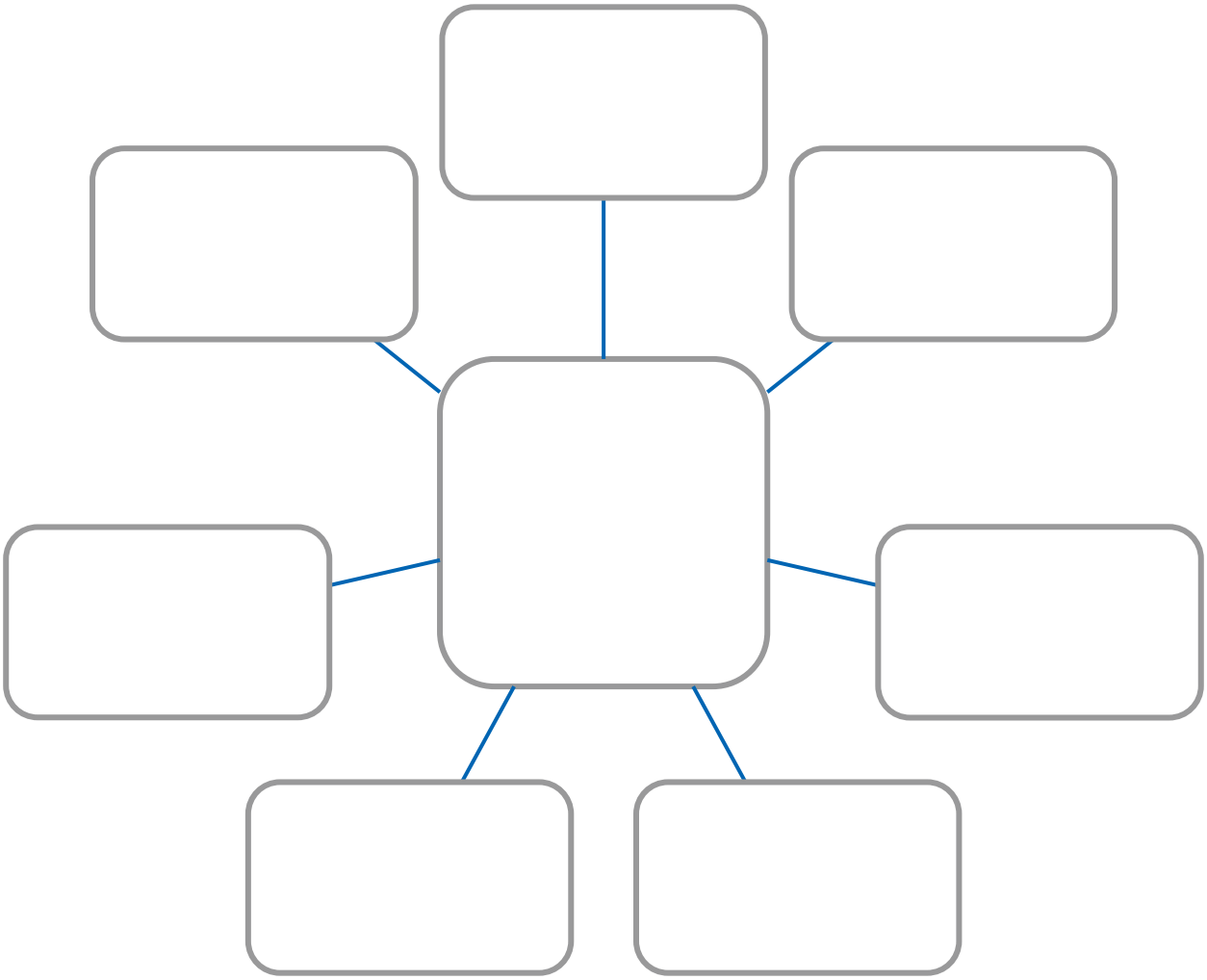
	How can we program a robot to navigate **any** path, without being controlled by a driver?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas



Building Design Scenario

Unit 7: Skill Development

SCENARIO:

You need to transport a vessel of water vertically, from one location (floor level) to another location that is at least 24 inches above floor level.

You need to design and build a device to accomplish this task using classroom resources and/or components from the Tetrix Kit of Parts or Matrix Kit of Parts.

- The device you design and build must be powered **without** the use of motors or electricity.
- It should effectively lower an empty vessel to the ground to be filled with water, and then lift the same vessel after it has been filled with a small quantity of water (at least 3 oz. or approximately 90 ml.).
- The device should sit on a chair or low table.
- The device should lift the vessel containing the water up from the floor level, to a height of at least 24 inches above floor level.
- The amount of water spilled from the vessel as it is raised, should not exceed 5% of the total amount when the vessel was filled.

Note: You will be using actual water for this challenge, so make sure the area and the device are clear of any electrical outlets or components.

DRIVING QUESTION:

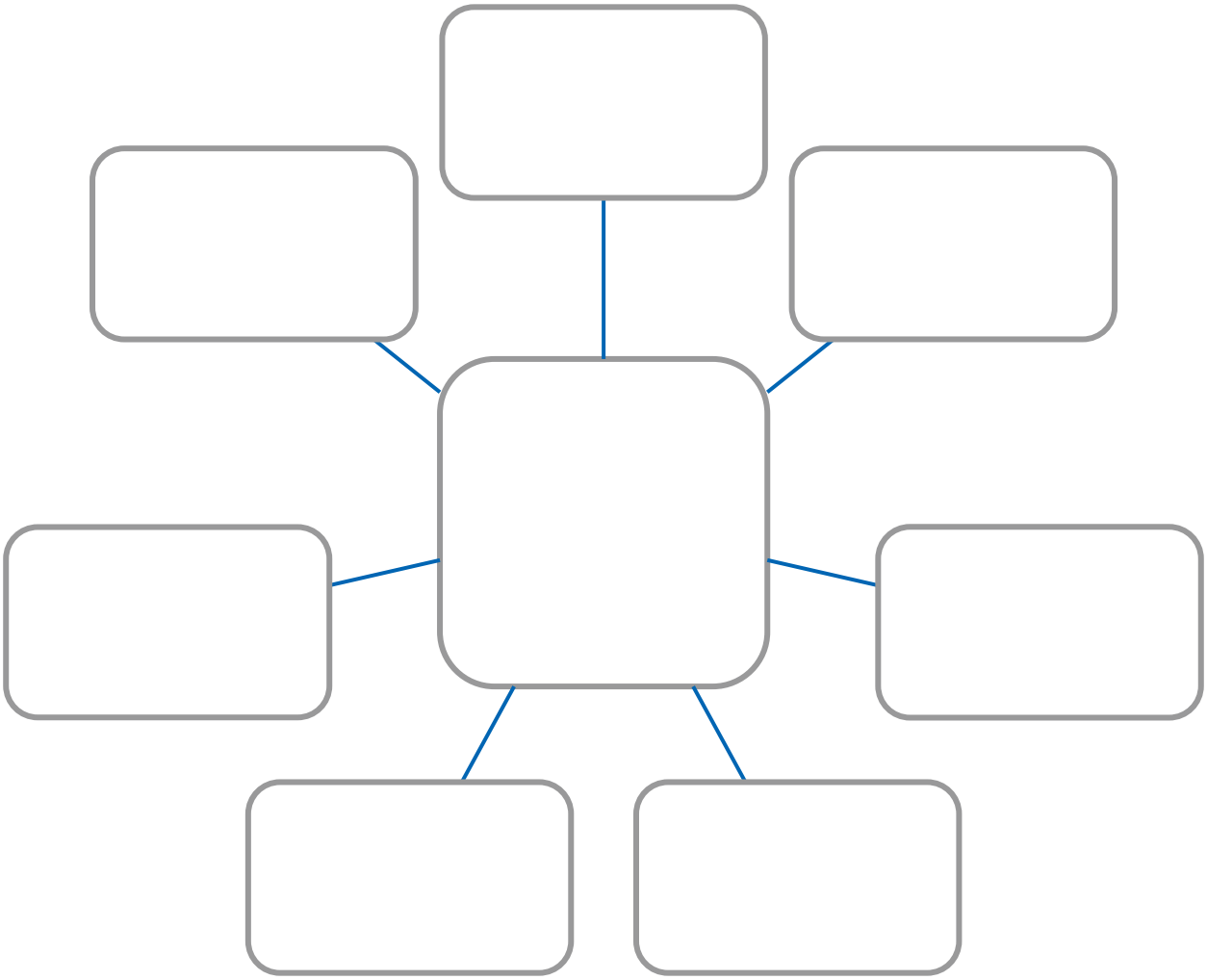
	How can available components be used to create a device that can lower an empty vessel and lift a vessel containing water?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Integrated Building Scenario

Unit 7: Skill Development

SCENARIO:

You need to safely transport a container of tiny objects that can easily spill (e.g., plastic beads, marbles, pebbles, dried rice or beans) from (floor level) to another location that is at least 24 inches above floor level.

You need to design and build a device to accomplish this task using classroom resources and/or components from the Tetrix Kit of Parts or Matrix Kit of Parts.

- The device you design and build must be motorized and operated using a remote control.
- It should effectively lower an empty vessel to collect the objects and then lift the same vessel after it has been filled to at least ¾ of the container's capacity, with the tiny objects.
- The device should sit on a chair or low table, and bring the vessel containing the objects up from the floor level.
- The device should lift the vessel containing the objects from the floor level, to a height of at least 24 inches above floor level.
- The weight of the contents in the vessel should be the same before and after it has been lifted (0%) loss.

DRIVING QUESTION:

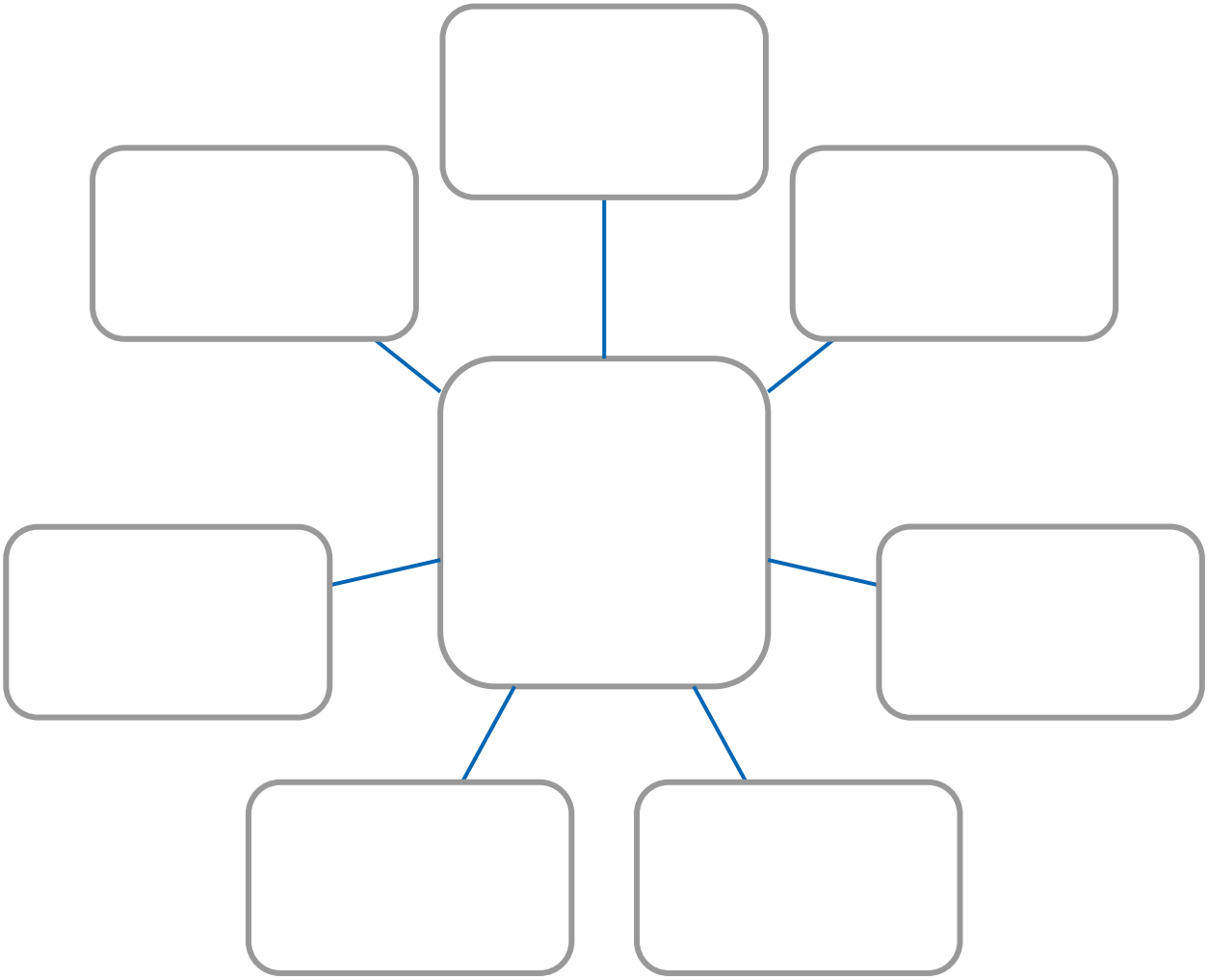
	How can classroom resources and/or components from the Tetrix Kit of Parts or Matrix Kit of Parts used to create a remote-controlled mechanism that can lower an empty vessel and lift a vessel containing contents that could easily spill?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



Engineering Notebook Scenario

Unit 7: Skill Development

SCENARIO:

Your team has asked you to improve the Engineering Notebook used for the *FIRST* Tech Challenge.

You have a few options to consider as you complete this challenge.

The overall goal is to update and enhance the format of the engineering notebook, but it's important to focus improvements with a clear, demonstrable objective.

Make the Engineering Notebook more usable in one of the following ways:

a) as a working document for collaboration.
b) as a searchable reference document.
c) as an esthetically enhanced presentation document.

DRIVING QUESTION:

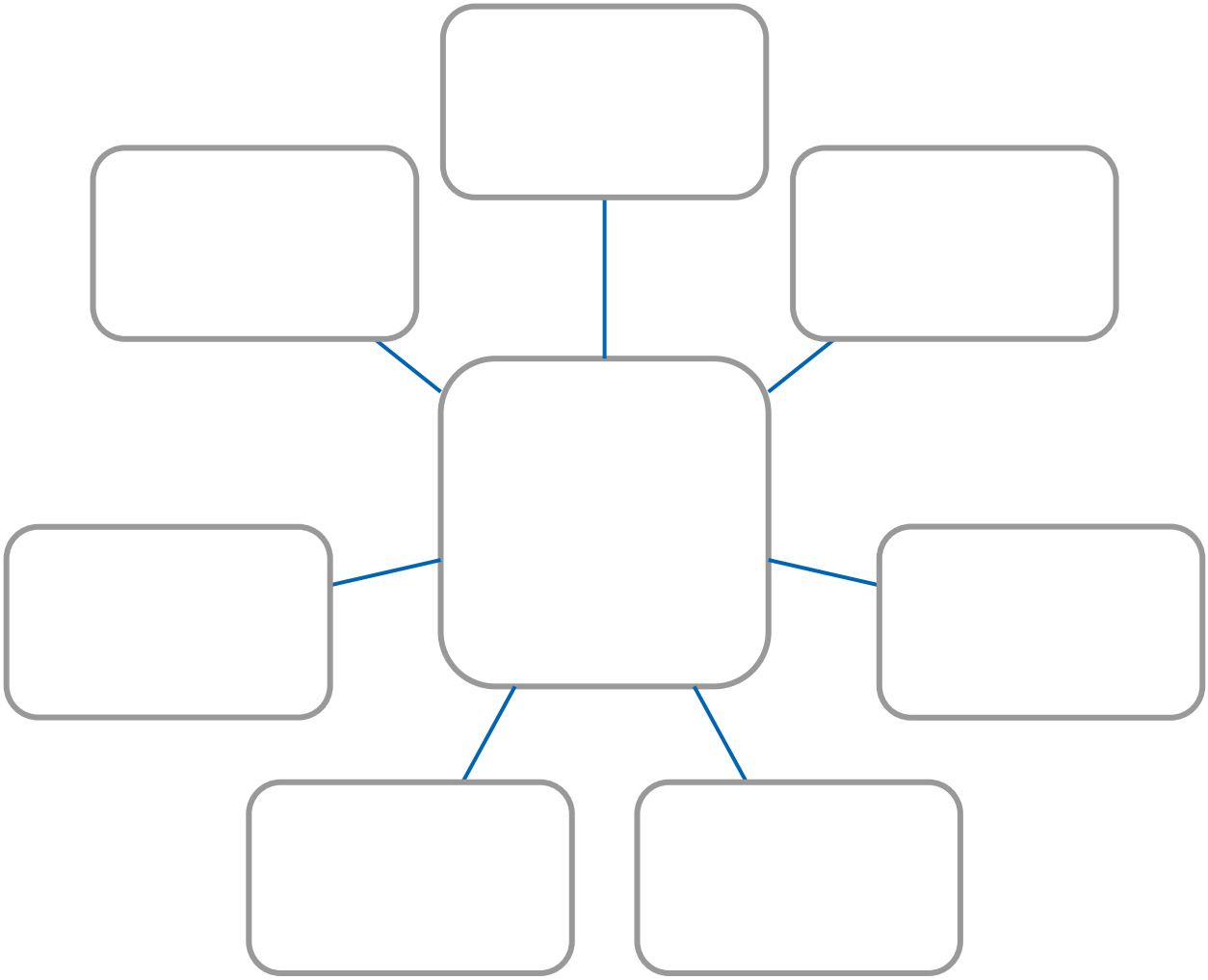
	How can you make your Engineering Notebook a more effective document and tool?

Is this the Driving Question you would like to answer? If not, make rough notes about any changes you would like to make to the Scenario or the Driving Question here.

What evidence will you provide to show that you have addressed this Driving Question?

Write your Driving Question for this scenario in the center square below and brainstorm the questions you will need to ask yourself or others to address it.

Use the template below or created your own mind map to document your ideas.



UNIT 8

Outreach and Community Building

UNIT OVERVIEW

UNIT NUMBER: 8

DURATION: Approximately 8 in-class hours or iterative if presentations will be completed at multiple post-season events

SUMMARY

In this unit, students will create an effective demonstration or interactive experience to implement in the wider community. Students will identify a target audience or event in the local area (e.g., a meeting with a local sponsor or student group, STEM Festival, STEM clubs or community events, group of public schools, maker's markets, other extracurricular clubs such as 4H or Scouts) and plan for a demonstration about their robot and their team.

INSTRUCTIONS

1. As a class, introduce the topic of outreach to the class and talk about some of the motivating factors that drive these kinds of initiatives.
2. Identify a local group or audience to target with the presentation. Talk about why this audience is important as a focus for outreach and what the class hopes to achieve by reaching out to them.
3. Divide the class into pairs or small groups of 3-4 students to conduct research or interviews. This information can be used to identify traits about the members of the audience that will help students tailor their presentation to the audience's needs or interests.
4. Plan for the presentation. Students will need to consider several different factors to shape and focus their presentation and create the resources necessary to deliver it. Planning may take place as a class, with smaller groups or pairs assigned to complete different tasks or deliver multiple presentations as needed. Planning may also be completed by dividing the class into smaller groups to develop and propose presentation ideas which can be synthesized into a single presentation by the class as a whole.
5. Create the presentation materials and have students work as a group (or in small groups if several presentations will take place) to practice.

LEARNING RESOURCES

***FIRST* Tech Challenge Outreach Resources**

- Fundraising Toolkit
- Fundraising Resources

General Marketing and Outreach Resources

- Creating a Stellar Elevator Pitch for your Non-Profit Organization
- The 6 New Non-profit Elevator Pitches (Video)
- How to Write an Elevator Speech

Online Presentation and Meeting Tools

- Google Slides

6. Deliver the presentation to the target audience at one or several planned events. Make sure to document it (photos, video) and plan to gather some feedback from the audience after the presentation. 7. Provide some time, after the presentation, for students to evaluate and reflect on the experience. Encourage them to work in small groups or pairs to consider what worked well, what didn't, and what they have learned for future presentations.	• Google Hangouts • Prezi for Education • Join Me Online Meeting

ASSESSMENTS:

1. Presentation Planner resource
2. Presentation Reflection resource
3. Rubrics

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Completed robot
3. Classroom materials or field kit
4. Art supplies (as needed)
5. Presentation software (as needed)
6. AV equipment, power cords, (as needed)

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

THE WHY?

UNDERSTANDING OUTREACH

The goal of outreach is generally to introduce or encourage some kind of participation in or support of an organization, program, or initiative. Often, the target population for outreach is a group of people who might not otherwise know about, be involved with, or have access to that organization, program, or initiative.

As noted on the *FIRST* Inspires website, the vision that drives *FIRST* is a goal to "transform our culture by creating a world where science and technology are celebrated and where young people dream of becoming science and technology leaders." (Dean Kamen, Founder).
Outreach activities and presentations help to build enthusiasm and support for the program, as well as for the fields of Science and Technology.

DEFINING THE GOAL(S) OF AN OUTREACH INITITATIVE:

Talk briefly about the concept of outreach and ask students to work in small groups to identify a few different outreach programs they have experienced in their day-to-day lives.

For each example, ask students to identify 2-3 goals that the initiative might have been trying to achieve.

Review the goals that students have identified for the outreach programs they have discussed. Create a master list of these goals on the board or poster paper.

Work together to identify and circle any outreach goals that inspire ideas for an outreach initiative around the *FIRST* experience or core values. Add additional, student-generated goals to the list as they come up.

Divide the class into pairs or small groups and provide them with the Presentation Planner resource.

Have them use the template provided or create their own to start the questioning process around the Driving Question.

DRIVING QUESTION:

	How can we, as a group of experienced *FIRST* participants, build a stronger relationship with the larger community in a way that is beneficial for everyone involved?

After considering ways in which they could try to build a stronger relationship with the larger community, encourage students to consider **why** they would.

What specific goals could this kind of outreach help them achieve?

Guiding Questions:

- What kinds of outreach and community building are other teams involved with? Why do you think they are motivated to do this? What goals are they trying to achieve?
- Why should **we** reach out to the larger community?
- How might we, as a class or team, benefit from this?
- How might the participants or attendees benefit from this?
- Which of the goals, listed here, are most important to our class or team? Why are these goals so important?
- How could we prioritize or rank these goals? What criteria would we use to do so?
- What is our primary goal in completing this outreach initiative? What are some secondary goals?

The Why? Facilitator's Tips:

Q: What are some examples of outreach initiatives that students may have encountered in their everyday lives?

A: Examples may include health initiatives, public education campaigns, or local non-profit organizations seeking financial or volunteer support.

Examples of outreach goals:

- An anti-smoking campaign
  - Inform smokers about the benefits of quitting
  - Help reduce the number of smokers in the local community by 30% in the next five years
- An employment and education initiative
  - Contact newcomers who are looking for work
  - Help newcomers enroll in online second language classes
  - Provide information about support services for job finding in the area
- An online webinar and live chat with young adults studying aeronautics
  - Develop interest in and deeper understanding of the program and field of study
  - Familiarize students with scholarships, grants, and funding opportunities

- Increase applications to programs in the field of aeronautics among students in certain demographics

Q: What might some of ***our*** goals be for an outreach initiative?

A: Some outreach goals that might apply to *FIRST* team outreach initiatives include:
- Building awareness (general education about *FIRST*, robotics, or STEM fields of study)
- Developing interest (recruiting for the future of the team or program)
- Encouraging participation (recruiting for current teams or programs)
- Gathering support (recruiting coaches, mentors, and other volunteers, or finding sponsors or other funding opportunities)
- Instilling pride in community and local students (showcasing what students have achieved or what they are working towards)
- Providing support (developing supportive networks or resources for new, struggling, or isolated teams)

Q: How can outreach activities benefit ***FIRST*** teams and the ***FIRST*** Community?

A: The *FIRST* Tech Challenge Mentor Manual includes a section called Outreach Activities for Teams (pg. 92-93), which outlines the advantages of outreach and provides examples of the kinds of activities many *FIRST* teams participate in. It also outlines a few suggestions on finding and creating outreach opportunities that are well-suited to the *FIRST* mission and objectives.

Q: Can outreach efforts help us move towards ***FIRST*** Tech Challenge Awards?

A: The Connect Award is given to the team that most connects with their local STEM community. Details about this award and its criteria can be found on the *FIRST* Inspires website.

THE WHO?

Once students have identified their goal(s) for an outreach initiative, it's time to consider the population that will benefit from the initiative and how to communicate with them effectively.

HINT:
Students will need to consider, not just general facts about the population they are interested in, but how familiar the individuals in that group might be with robotics, and what will pique their interest. It's important that the presentation is a positive, engaging experience, regardless of age or background.

The audience for the presentation may respond well to a standard presentation, or they may be more engaged by an interactive game, demonstration, or hands-on instructional workshop. The audience may be made up of local community members, but may also be a team half-way around the world.

The Driving Question for this unit focuses on building a relationship with the larger community in a way that is beneficial for everyone involved. Students should be encouraged to consider, not just who they would benefit from contacting or engaging, but also who would benefit from learning more about *FIRST* and/or the class' achievements and experience.

As a class, select a target population, based on the goal(s) outlines in the "Why?" section of this Unit.

Provide students with time in small groups to brainstorm a list of questions they need to investigate or to ask others to get more familiar with the population they are seeking to contact.

Use the "Knows and Need-to-Knows" table provided on the Presentation Planning resource to document questions that will need to be asked about the target population and details about them as they are discovered.

Information documented here can be used to create a sample profile of a "person" that students will be communicating with. Students should think about this fictional "person" to help them as they shape the kind of presentation they will propose in the next section of this unit, just as a teacher would consider the type of learner they would be working with.

HINT:
This may be a challenging task for some students. It may be a good idea to create a sample profile together as a class before encouraging students to look at the information they have gathered to try and create their own. Profiles don't need to be long or detailed. Try to select 3-5 important points about a person's age, experience, and interests to include in bullet form.

Guiding Questions to ask about the Audience:

- What do we know about the population we wish to reach?
  - Age
  - Grade
  - Gender
  - Cultural background
  - Profession
  - Languages spoken or understood
  - Hobbies or interests
- Where can these people be reached?
  - Online
  - Local schools
  - Community groups
  - Local businesses
  - Extracurricular groups (e.g., Scouts, 4H, team tournaments)
  - Public places (e.g., shopping centers, community centers)
- What kind of experience do they have with *FIRST*?
  - None
  - *FIRST* LEGO League Jr.
  - *FIRST* LEGO League
  - *FIRST* Tech Challenge
  - *FIRST* Robotics Competition
  - *FIRST* Mentors/Sponsors/Alumni/Family Members
- What kind of experience do they have with robotics?
  - None
  - General awareness from TV, movies, etc.
  - Playing with toy robots
  - Using robots in daily life (e.g., household robots that vacuum)
  - Working with robots (e.g., work in manufacturing)
  - Programming experience
  - Building experience
  - Engineering or professional experience in robot design or use
- Will there be any barriers to their understanding of what we are talking about or showing them?
  - Previous experience with robots or similar technology
  - Language spoken or understood
  - Learning style (e.g., younger and need short explanation and opportunities to play, older and able to sit through a longer explanation and demonstration)
  - Ability to understand and follow instructions
  - Safety considerations
  - Enthusiasm or lack of interest
- Can they benefit from our experience? If so, how?
- If they cannot benefit from our experience, is this an appropriate individual or target population for our presentation?
  - Should we revisit the Driving Question or focus on a different profile or individual who might benefit more from participation?

The Who? Facilitator's Tips:

Q: What is a target population?

A: A target population is a group of people that you want to contact, engage with, and get involved in the kinds of things you do. Who you want to engage with your outreach presentation will be connected to the goals you want to achieve.

Sample Goals for Outreach:	Possible Target Population:
Recruit new members for an upcoming season.	Local junior high school students Students who are already involved in extracurricular clubs or activities
Build awareness of *FIRST* programs available for students within the local community.	Local elementary school students Local extracurricular groups Families passing through shopping centers Families at community centers
Find new team sponsors.	Local business organizations Friends and family members of team participants
Support students who are interested in robotics but live in remote regions.	Classes in other communities (online) Other *FIRST* teams Home school or remote schooling organizations

Q: Why is it important to create a profile of an individual from the target population?

A: It can be very overwhelming to try and meet the needs and interests of everybody, at all times. To help focus the presentation and make sure that it is meaningful to participants, it's useful to learn a little bit about them. A profile of a sample individual is a useful reference point to revisit as ideas are developed. It is not intended as a complete description of any individual who might be present at the presentation, but rather a way to put a face on the kind of person students will be interacting with. For example, students can ask themselves if this individual would understand the robotics jargon or terminology they are using, or if the individual would be able to operate the joystick independently for an activity they are creating.

However, it's also important to note that people can be surprising. There are always exceptions to every assumption or general understanding about people. Students should be prepared for situations where their expectations are not accurate, and practice a few ways to adapt their presentation accordingly.

Q: What if every group creates a different profile with different needs or experience?

A: This will likely happen and is not a bad thing. Select or post a 3-4 of the profiles and use them as a random sample of the kinds of people that might participate in the presentation. Encourage students to consider ways in which each one of these individuals would benefit from participating in their outreach initiative.

THE WHAT?

Now that students have determined goals for their outreach initiative and learned a little bit about the population they will be engaging, it's time for them to think about what their presentation will look like and how they will put it together.

Post the goal(s) of the presentation where they are clearly visible in the room.

Divide the class into small groups to brainstorm ideas for a presentation, demonstration, or interactive activity they could develop to accomplish their goal, that would also connect with the audience they are trying to reach.

Three important questions to ask are:

1. What are we going to do?
2. What do we want to "walk away" with? (What will **we** gain from participating in this presentation?)

3. What do we want the people who participate in our presentation, to "walk away" with? (What will **they** gain from participating?)

HINT:
Make sure students understand that their presentation can take many forms, depending on their goals. Encourage them to think beyond a basic Power Point or display board presentation, especially if they will be engaging with young students or community members who are not familiar or comfortable with robotics.

As students are brainstorming and refining their ideas on the Presentation Planning resource, encourage them to consider and discuss the questions below.

Guiding Questions about the Presentation:

- Will there be one presentation, given one time, or several presentations delivered to different groups?
  - All at same location by same people or at different locations by different people?
- How will we get people interested in our presentation?
  - "Cold calls" or stopping passers-by
  - Networking
  - Creating an elevator pitch to quickly explain goal(s) and benefits
  - Visuals, music, or other presentation aids
  - Incentive or team SWAG for participation
- How can we be inclusive in our presentation?
  - Attract people from different backgrounds, age groups, grades, gender, clubs, or organizations
  - Include audience members who may have visual, hearing, or physical impairments
- Where will the presentation take place and how will this affect what we can do for our presentation?
  - Online, recorded, or in-person
  - Size and shape of space (front of classroom vs. open gym in a community center)
  - How many people can be included in the presentation?
    - As presenters
    - As viewers
    - As participants
  - Noise level
    - How much noise can we make?
    - How can we ensure we are heard and understood?
  - Seating arrangement or ability to move around during presentation
    - Will we, as presenters, be able to move around?
    - Will participants be able to move around?
  - Electrical outlets, lighting, sound systems, and Wi-Fi access
  - Material that will be available there to use (e.g., tables, extension cords, sound system, duct tape, markers and paper, etc.)
- Is there anything that participants should physically actually "take away" with them?
  - Posters
  - Flyers
  - Team business cards
  - Email or website information for future contact or to learn more
  - Team SWAG or participation incentives

The What? Facilitator's Tips:

Q: What kinds of presentations or demonstrations can students do?

A: Presentations make take many forms, with various levels of interaction. Students may wish to incorporate materials or components of presentations that they've created throughout the game season, or they may wish to start from scratch. Possibilities are limited only by resources, and time to prepare.
Examples of potential presentations:

- Live demonstration of a simplified *FIRST* Tech game challenge to show sponsors what the team has achieved with their support
- Video demonstrations for community groups or individuals involved with fundraising efforts (e.g., Thank you for your support! Here is what your support allows us to do.)
- Live demonstrations or simplified game challenges at schools or clubs for recruitment purposes
- "How to" or "Help" video tutorial collection to support and mentor new teams or *FIRST* LEGO League/*FIRST* LEGO League Jr. teams (e.g., This is the problem we faced and this is how we approached it. Here is the type of experience you can gain in the *FIRST* Tech Challenge.)
- Peer-to-peer mentorship via webinar or live chat with another team (in a neighboring community or in another region) sharing challenges faced and accomplishments or solutions.
- Interactive robot center activities on parent's night, with students acting as mentors at each one
- Video pitch presentation for potential sponsors to explain the benefits of involvement with *FIRST* robotics or students studying STEM topics

Q: How can students prepare to interact with people who are not familiar with robotics?

A: It may be a good idea to have students develop and practice a basic "elevator pitch" about their team, what they are doing, and why they are doing it. Preparing and practicing an elevator pitch can help engage audience members or passers by, and help students communicate key points about their presentation confidently and concisely.

It's important for students to understand that an elevator pitch should be easily understood, regardless of experience or background. It should be 30 seconds to 1 minute long (maximum) and include key points about their team, their goals, and their presentation in plain, clear language that makes sense to their target population.

This is a challenging task, both to write and to delivery naturally once the pitch has been developed, however, it is a skill that will benefit students as they complete interviews and presentations within *FIRST,* or seek employment in the future.

A few different websites with more information about these kinds of summaries have been provided below.

- Creating a Stellar Elevator Pitch for your Non-Profit Organization
- The 6 New Non-profit Elevator Pitches (Video)
- How to Write an Elevator Speech
- TED Ed: How to Perfect the Elevator Pitch

It is also a good idea to conduct a few practice runs of the presentation with others within the school community or with friends and family members. This will help to develop confidence, to work the bugs out of the presentation flow or materials, and to gain an idea of the kinds of questions people might ask. If completing the presentation or demonstration online, this will also provide an opportunity to work through any technical problems that may arise on presentation day.

THE HOW?

Work together as a class to make a list of all tasks and subtasks that will need to be completed to prepare for the presentation. If several different presentations will be taking place, ask students to do this with their groups.

Students should then create a timeline or plan to complete the presentation, keeping in mind when and where the presentation will take place, how many individuals will be participating, and if relevant, what the presentation space (real or virtual) should look like.

HINT:
Make sure to encourage students to take on new or unfamiliar jobs or tasks. This unit provides an opportunity to revisit or build upon some of the skill development goals that were targeted in Unit 7.

Guiding Questions for Planning the Presentation:

- Make a list of the jobs that will need to be done.

    - Who has experience with those jobs?
    - Who would like experience with those jobs?
    - In what order will they need to be completed?
    - Can any of the tasks be completed in parallel, at the same time, by different people?
    - Estimated completion time
- Make a list of the resources you have available.
- Make a list of materials that will be needed:
    - What needs to be made?
    - What needs to be gathered?
- How will the different parts of the presentation flow together?
    - Flow chart of presentation with:
        - An introduction or "hook" to get the audience excited about the presentation
        - Brief descriptions of the different steps or activities in the presentation or event
        - Notes about how long each step or activity might take
        - Notes about materials needed for each step
- What will the presentation look like?
    - On screen (if presenting online)
    - Vendor-style booth set up
    - "Bird's eye" view (map) of centers and presentation components (e.g., Where will presenters stand? Where will the robot course be? Where will the robots be stored? How will participants move around the space?)
- How can we best communicate what participants need to do?
- Will we need to prepare written, visual, or verbal instructions for participants?
- How can we gather feedback or exchange contact information (if necessary or desired) from participants during or after the presentation?

The How? Facilitator's Tips:

Q: How can students work together to plan their presentations?

A: As with any process, the development of a flowchart or timeline can be helpful in visualizing the components of and progress through a presentation. Students can create a very detailed version of this and then remove details as they practice and become more familiar with their presentation.

PRESENT AND REFLECT

After the presentation, provide students with some time to discuss how the presentation went.

Were the goals they outlined at the beginning of the unit accomplished?

Divide students into small groups or have them sit with their presentation group. One-by-one, ask students to share a few points or general impressions about the presentation with one student acting as a note taker.

After this, students may be encouraged to synthesize individual experiences into a group-based evaluation, or they may complete individual reflections and note areas where their impressions of the event aligned with or differed from other group members.

HINT:
It's important to note that two individuals make walk away from the same presentation and feel very differently about the experience. Respectful differences of opinion should be welcomed and discussed, but it is important that discussion continues to reflect the Core Values of Gracious Professionalism® and Coopertition®.

Provide students with the Presentation Reflection resource and have them complete a self-evaluation of the presentation or event and their role in it.

Guiding Questions for Present and Reflect:

- What went well?
- What didn't go well?
- How did the audience react? What did they have to say about it? Did you gather feedback formally or informally?
- What kinds of questions did they ask or comments did they make?
- What would you do the same next time?
- What would you do differently next time?
- What have you personally gained from this experience? (e.g., new communication skills, learned to use a new presentation tool or technique, gained confidence in ability to present to an audience)
- What are the next steps for your class or team? (e.g., incorporate elements of the presentation or materials into the Engineering Notebook or *FIRST* Tech challenge presentations in the future, continue to develop the relationship with the target population through future events or mentoring)

Present and Reflect Facilitator's Tips:

Q: How can this experience be integrated into or represented in the Engineering notebook?

A: Gather photos of the event, planning material, screen shots of material created or online presentation snapshots. If possible, document testimonials or feedback from participants about the event. Use word processing, Power Point, or layout software to create a 1-page visual summary of the event and include it as a PDF in the Engineering Notebook or as a download about the team's outreach efforts on a team website.

Presentation Reflection

Unit 8: Skill Development

Name: Date:

In your own words, describe the goal of the presentation or event that you completed and how the presentation or event achieved that goal.

HINT: If you created an elevator pitch for your presentation, it can help you answer this question.

How successful do you think the presentation or event was at achieving this goal?

We did not achieve any of our goals.	We achieved one or some of our secondary goals.	We achieved our primary goal.	We achieved all of our goals and more.
Comments:			

How appropriate was the presentation or event for the target population?

It was not appropriate.	It was appropriate in some ways but many of the participants weren't interested.	It was appropriate and most of the participants were interested.	It was appropriate and engaging for all participants.
Comments:			

How effective were the materials used for the presentation or event?

They did not work well.	They worked ok. There were some problems with them.	They worked well.	They worked better than we expected.
Comments:			

How would you describe your participation in the presentation?

I contributed very little to the presentation.	I contributed to the preparation for the event but did not participate in the presentation.	I contributed to the preparation for the event and participated in the presentation.	I took a leadership role in the preparation, planning, and/or delivery of the presentation.
Comments:			

What will you do again in future presentations?

What won't you do again in future presentations?

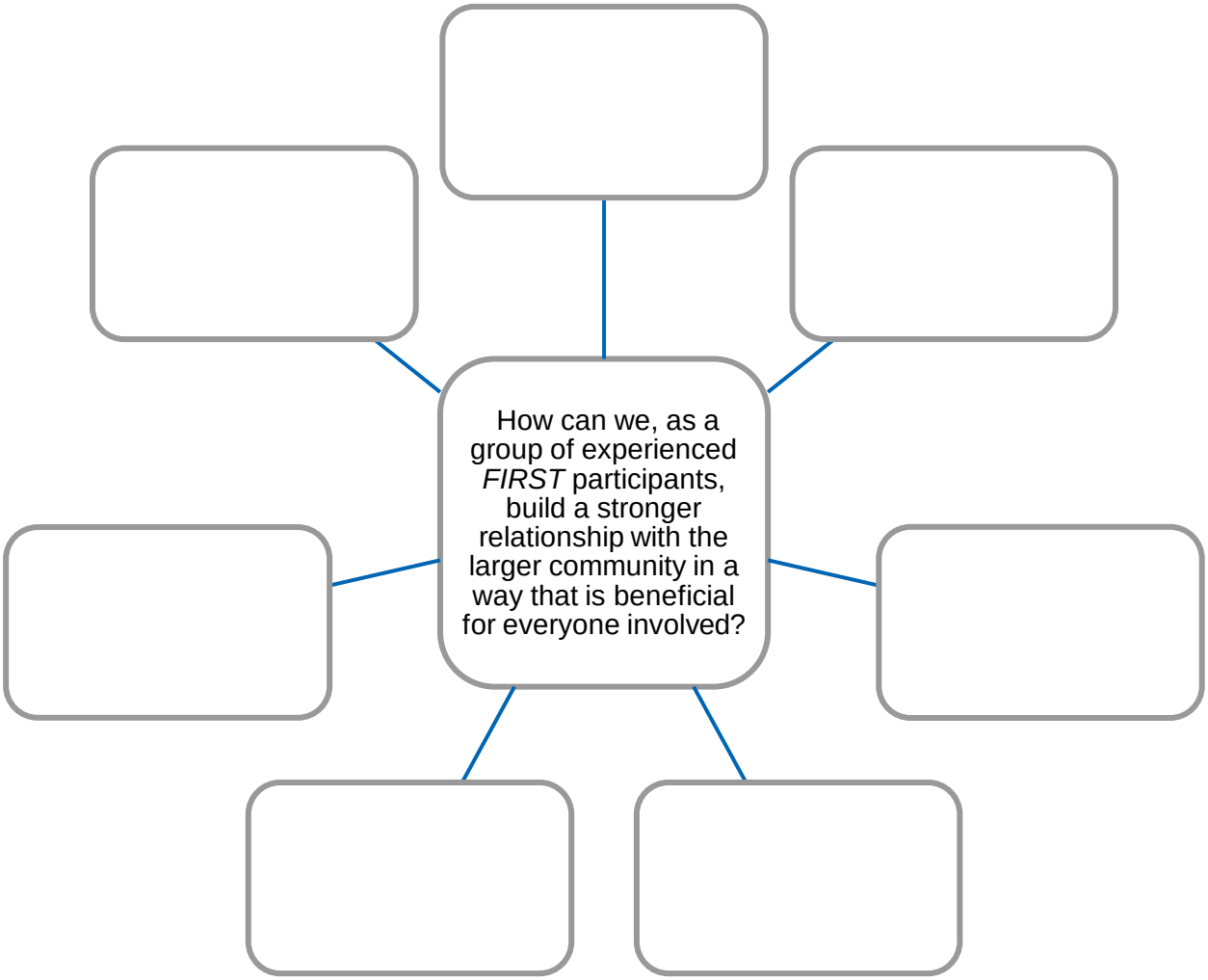
Describe one important lesson you have learned from this experience.

Use the template below or create your own to consider and ask questions about the Driving Question below.

If these are the ways in which you **could** help to build a stronger relationship with a larger community, **why** would you?

Make a list of some of the goals this kind of outreach could help accomplish?

-



-
-
-
-

The Who?

Unit 8: Outreach and Community Building

KNOWs	NEED-TO-KNOWs
What do we **know** about the population we wish to reach?	What do we **need** to know about the population we wish to reach?

Look at some of the points you've written about the population you will be working with.

Select the most important points and write a short profile of a person who you'd like to reach.

The What?

Unit 8: Outreach and Community Building

BRAINSTORM PRESENTATION IDEAS:

Brainstorm ideas for a presentation, demonstration, activity, or event that might help you achieve the goal(s) you have selected for your outreach activity.

Try to think about:

- What would be interesting or helpful for the person in the profile you created.
- Different kinds of presentations or activities
- Where the presentation might take place (virtual or live)
- What kinds of resources or materials you have to use

Try to write one idea in each box.

REFINE PRESENTATION IDEAS:

- Circle the ideas that you think might be most enjoyable or interesting for your target population.
- Draw a line through ideas that you think may not be very interesting for participants or that might be too complicated or difficult to achieve.

  Think about:

  - The resources you have available
  - How much time you and your class have to work on the presentation
  - Where or how you could do the presentation and what would be possible in that space (virtual or live)
  - What kinds of things you would need to develop a successful presentation
- Draw a ☆ in the boxes with the best ideas.

  HINT: There might be more than one idea that would work well or there may be a few ideas that could be combined.

Think about the ideas you've selected with a ☆ and describe the outreach presentation you would like to plan here:

The How?

Unit 8: Outreach and Community Building

Use the template below or make your own timeline or checklist to complete the outreach presentation you have selected.

Task	Resources Needed	Estimated Completion Date	Team Members Responsible

What will the presentation or event include and how will all its parts flow together?

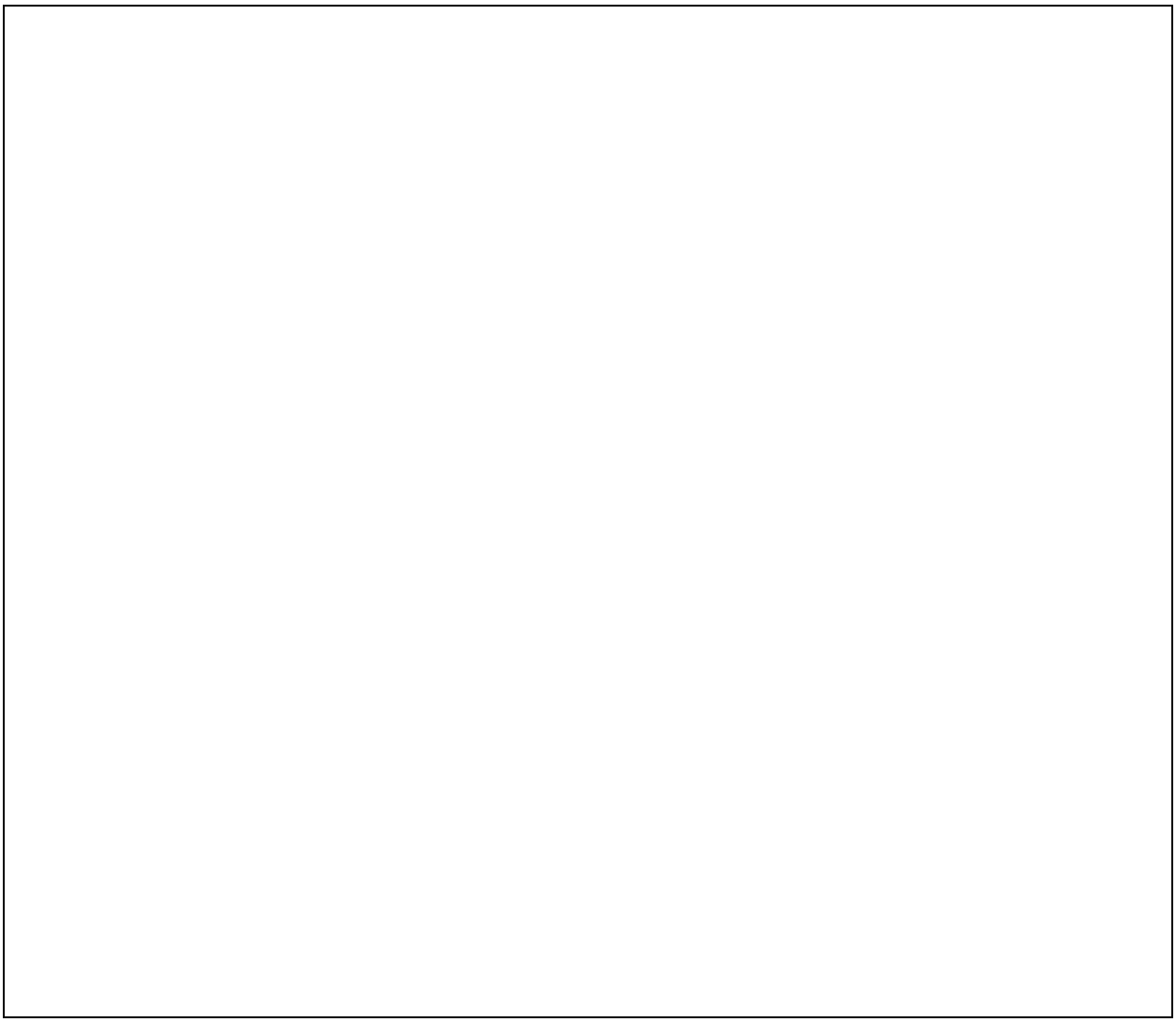
Use the space below or to create a flowchart, timeline, or mind map of your presentation or event.

Make sure to include:

- An introduction or “hook” to get the audience excited about the presentation
- Details about each step and how long each step or activity might take
- Details about materials needed for each step
- A conclusion to wrap up the presentation and let the participants know what they have accomplished.

What will your presentation space look like?

Use the space below to draw a floor plan for a live presentation or event, or a sketch of what the screen would look like for viewers at a virtual event.



UNIT 9

New Game

UNIT OVERVIEW

UNIT NUMBER: 9

DURATION: Up to 15 in-class hours (depending on complexity of game and means of implementation)

SUMMARY

In this unit, students will think critically about their experience with previous units and apply the skills they've developed to create an original *FIRST* Tech Challenge Game. They will use a thematic scenario as the inspiration for original game design and incorporate elements from previous challenges into the game play, using commonly available materials from around the school or classroom. Skills developed in outreach efforts will be applied to teach another group of students or community members how to play their game.

INSTRUCTIONS

1. Divide the class into small groups and encourage students to brainstorm and list on chart paper three of their favorite elements of game play or strategy from their previous experience in *FIRST* Tech Challenge. They should briefly explain why they liked them so much. Have the groups share these ideas with the class and then complete the same activity with their least favorite elements of game play or strategy. Post these lists in the classroom to view throughout the design phase.
2. As a class, review and discuss the Ship it! Warehouse Scenario resource.
3. Divide the class into small groups again to brainstorm or incorporate ideas from previous brainstorming, into an initial idea for a new game that meets the scenario and criteria provided.
4. In groups, or as a class (depending on available resources), create a plan to develop and test the new game idea. Provide students with the Game Design resource to document their plan, ideas, and progress.
5. Complete and test the new game. This can be completed in small groups if resources allow, but may need to be completed as a class if materials or space is limited.

6. Have students share their game or teach it to new players. Teams may wish to exchange original game challenges and complete them individually, or gather together in a full-day scrimmage workshop to learn and adapt to the games on-the-fly.

Teachers may wish to have students complete formal or informal presentations about their games. Students should reflect on the game design experience and what they have learned from it.

ASSESSMENTS:

1. Weekly Engineering Notebook
2. Weekly Self & Peer Evaluation
3. Ship it! Warehouse Scenario resource
4. Game Design Process resource
5. Unit 9 Rubric

TOOLS & MATERIALS

1. Tetrix Kit of Parts or Rev Kit of Parts
2. Completed robot
3. Classroom materials or field kit
4. Art supplies (as needed)
5. Electrical tape in various colors
6. Found items such as:
    1. Cardboard boxes, boards, safety cones, benches turned on their sides to create barriers
    2. Balls of different sizes, plastic cups or lunch containers, stuffed toys, books, cans or boxes of non-perishable food as items to select
    3. Plastic storage bins of different sizes
    4. PVC or cardboard tubes to create "portals"

STANDARDS ADDRESSED:

Full course standards alignments can be found here.

NEW GAME CHALLENGE

Ship it! Warehouse Game Scenario:
What would you do if you could design a FIRST Tech Challenge Game?

You and your teammates have been selected to develop a new game that can be created using the field kit and/or everyday classroom materials.

This game theme is set in a semi-automated warehouse where items are stored in one area of the playing field to be selected by a robot that is "shopping." The items must then be "shipped" to various locations via portals in another area of the playing field.

Robots will need to complete their shopping and shipping task without dropping their items and without colliding with obstacles or other robots completing the same task. The game you design must meet the criteria below.

Ship it! Warehouse Game Criteria:

1. The field must have at least two sections:
    1. Storage (where items are kept for selection and transportation)
    2. Shipping (the area on the field that contains the "portals" to different locations)
2. Part one of the game must be autonomously controlled.
    1. In this part of the game, the robot should drive to select one item out of three options located in the "Storage" section of the field.
    2. (Optional) Each item may be worth a different value.
    3. The item should be selected and transported to a transition point on the game field where the remote-controlled portion of the game will begin.
3. Part two of the game must be remote controlled.
    1. Once the items have been selected and transported to the transition point, the robot needs to drive and move them to one of three shipping portals located in the "Shipping" section of the field.
    2. (Optional) Each portal may be worth a different value.
4. Two robots must complete this task at the same time.
5. At least two obstacles must be present on the game field.

The rest, is up to you!

HINT:
Remember, someone else is going to have to play your game. Make sure to test it for difficulty, playability, and fun!

DRIVING QUESTION:

How can we, as a team of experienced *FIRST* Tech Challenge participants, use what we've learned about design, programming, building, and communication, to create a fun, challenging robotics game that other students can play?

HINT:
When students are considering the challenge and what they will incorporate into their own game, they should be encouraged to "keep it simple" and add complexity as ideas are developed and tested. They will ultimately need to teach other students about their game, so the tasks, rules, and scoring they incorporate should be both attainable and reasonably easy to understand.

Guiding Questions:

- What questions do we have about the challenge?
- Are there clear answers to all of these questions or is there "wiggle room" to innovate and make up our own answers?
- What does this challenge make us think of?
    - Real world situations or examples
- Are there other challenges we've completed that might contain useful game elements or ideas for game play?
- Where can we find information about old games or look for inspiration?
- What have we learned in previous units that will help us complete this challenge?
    - Generating ideas
    - Design skills, tasks, or ideas
    - Programming skills, tasks, or ideas
    - Building skills, tasks, or ideas
    - Communication and presentation skills or tools

Facilitator's Tips:

Q: Where can students find archived game material for inspiration?

A: A playlist of previous *FIRST* Tech Challenge game animations can be found here.

Q: How can this game scenario be adjusted for greater or less complexity?

A: Additional and optional challenge ideas have been included in the Facilitator's Tips in the Design and Complete the Game phase of this unit.

DESIGN AND COMPLETE THE GAME

Provide students with the Game Design Process resource. Divide the class into small groups and have them work through the process, using the resource to document their ideas and progress.

Use the DESIGN THE GAME and MAKE A PLAN sections of the resource to document ideas and progress.

The final game may be completed by small groups if resources allow, or groups may come together and share ideas to create a single collaborative game. If a collaborative game is the goal, it's a good

idea to use a fresh copy of the Game Design Process resource to document the final product after groups have used individual copies for brainstorming and idea development.

To encourage critical thinking about game design, encourage students to brainstorm their own questions that will need to be asked to design an engaging, playable game. To support students and teachers in this process, a list of guiding questions has been provided below to be used as needed.

Guiding Questions:

- What resources do we have to build the game field and elements on the game field?
- How big should the "warehouse" be? How much space do we have to set up and play the game as it is developed?
- Will we need to take apart or store the game during the development process? Will it need to be easy to disassemble and store?
- What are the basic criteria?
- What additional criteria will we add?
- How will the game be scored or won?
    - Will each item have a different value based on size, color, placement, or how easily it can be picked up or transported?
    - Will each portal have a different value based on size in relation to the items, placement, or level of difficulty in navigation towards it?
- Will the game or parts of the game be timed or will there be time limits?
- Will the Pushbot or another robot made for this year's *FIRST* Tech Challenge be an appropriate size or include appropriate components for this game?
    - Will modifications need to be made to the robot to complete it?
    - How extensive or complicated will those modifications be and will players be able to make them?
- What programming elements can we use that we gained in the skill development unit? (e.g., Include a Path to portals that robots can be programmed to follow autonomously.)
- What building elements can we use that were in skill development? (e.g., Incorporate the transportation of a container that can spill among the items to be "shipped.")
- What tools do we have to plan and test our game? (e.g., Use CAD to design the field.)
- Could we explain this to someone? Who will be playing and how can we effectively explain the game to them? (e.g., Create a video demo of the game to post online so a team in another part of the country or world can learn to play it.)
- Would another team in another location be able to set this up based on our instructions and play this? (e.g., Use the communication strategies from the Problem Solving and Communication challenge in Unit 7 to break down and represent the information.)
- Do we have enough time to create this game?
- How will we test the game?
    - How will you determine if it's too easy, too hard, or just hard enough?
- How will we teach people to play it?
- How much time will players need to understand the game and to develop a robot and program that works to complete it?

Additional (Optional) Challenges:

- Create two or three different versions of the same game to accommodate skill level or experience of players (e.g., Beginner, Intermediate and Advanced Levels of game play).
- Design the game field in CAD or using open-source software.
- Design a game where three items must be selected and transported to specified portals. Items may need to be collected at once and stored, or the remote and autonomous portions of the game may need to be repeated for each item to be selected and then "shipped' individually.
- Design a game that can be completed entirely using a remote control to practice driving skills.
- Design a came to be completed autonomously to practice more advanced programming skills.
- Use the new game for a community outreach effort.
- Incorporate the new game into local scrimmages with other *FIRST* Tech Challenge teams.
- Use open source video editing, graphic design, or animation software to create a professional-looking instructional video about the game so other teams in the *FIRST* community can view and play it.

HINT:
Encourage students to build and test their games several times throughout the development process, documenting problems encountered and solutions discovered on their Game Design resource.

Facilitator's Tips:

Q: What materials or resources should students incorporate into their game?

A: The list of available materials and resources may vary from school to school or classroom to classroom. Students should be encouraged to think critically and resourcefully about what is available to them to use without purchasing additional materials. It may be a good idea to provide time for students to investigate their school, home, or community for opportunities to reclaim, reuse, or repurpose found or scrap materials.
Below is a list of suggested materials to use as a starting point.

Suggested Resources to Build the Game and Field:

- Tetrix Kit of Parts or Rev Kit of Parts
- *FIRST* Tech Challenge field kit
- Art supplies (as needed)
- Electrical tape in various colors
- Found items such as:
    - Cardboard boxes, boards, safety cones, benches turned on their sides to create barriers
    - Balls of different sizes, plastic cups or lunch containers, stuffed toys, books, cans or boxes of non-perishable food as items to select
    - Plastic storage bins of different sizes
    - PVC piping or cardboard tubes to create "portals"

Q: How can games and student participation be assessed?

A: Teachers may wish to have their students complete formal presentations of their game design, using the Game Design Process resource as a template for the elements that should be represented in final project documentation.
This may take the form of:

- A formal proposal developed to present to a fictional committee of *FIRST* game designers as a potential scenario for next year's *FIRST* Tech Challenge
- An Elevator Pitch (see Unit 8) and face-to-face interview about the game and how it was developed and tested

A general rubric has been provided with this unit for teachers to adapt to their needs and their students' levels.

REFLECT ON GAMEPLAY

Encourage students to create instructional material to demonstrate or teach a new group of players about their game. This may be in the form of instructional print outs, posters, video tutorials, or in-person demonstrations and coaching.

Students should share their game with another team and gather feedback and questions, or if possible, observe as another team completes the game challenge they've created.

Depending on the complexity of the game and the kinds of programming or robot modifications required, this may be possible in a one-day workshop, or may require a few weeks between presenting the game and observing the game so that the teams playing it have time to consider and prepare to complete the game challenge.

Alternatively, students can complete their game and play it themselves, following the iterative engineering design process they've learned throughout the *FIRST* Tech Challenge.

When students have completed this experience, return to the Game Design Process resource and encourage them to complete the TEST THE GAME and REFLECT ON THE GAME DESIGN EXPERIENCE sections.

Facilitator's Tip:

Q: How can this Unit be used to build stronger *FIRST* teams?

A: In the off-season, new games that have been generated can be exchanged between teams to support innovative problem solving and skill development without the risk or pressure of competition. Teams can get together and play each other's games in scrimmages and novel solutions to problems that the game presents can be shared. Networking and sharing can be done face-to-face, or online via the exchange of demo videos and video documentation or live streaming as the student-generated challenges are completed.

Ship it! Warehouse Scenario

SCENARIO:

What would you do if you could design a *FIRST* Tech Challenge Game?

You and your teammates have been selected to develop a new game that can be created using the field kit and/or everyday classroom materials.

This game theme is set in a semi-automated warehouse where items are stored in one area of the playing field to be selected by a robot that is "shopping." The items must then be "shipped" to various locations via portals in another area of the playing field.

Robots will need to complete their shopping and shipping task without dropping their items and without colliding with obstacles or other robots completing the same task. The game you design must meet the criteria below.

Ship it! Warehouse Game Criteria:

1. The field must have at least two sections:
    - Storage (where items are kept for selection and transportation)
    - Shipping (the area on the field that contains the "portals" to different locations)
2. Part one of the game must be autonomously controlled.
    - In this part of the game, the robot should drive to select **one** item out of three options located in the "Storage" section of the field.
    - *(Optional)* Each item may be worth a different value.
    - The item should be selected and transported to a transition point on the game field where the remote controlled portion of the game will begin.
3. Part two of the game must be remote controlled.
    - Once the items have been selected and transported to the transition point, the robot needs to drive and move them to **one** of three shipping portals located in the "Shipping" section of the field.
    - *(Optional)* Each portal may be worth a different value.
4. Two robots must complete this task at the same time.
5. At least two obstacles must be present on the game field.

The rest, is up to you!

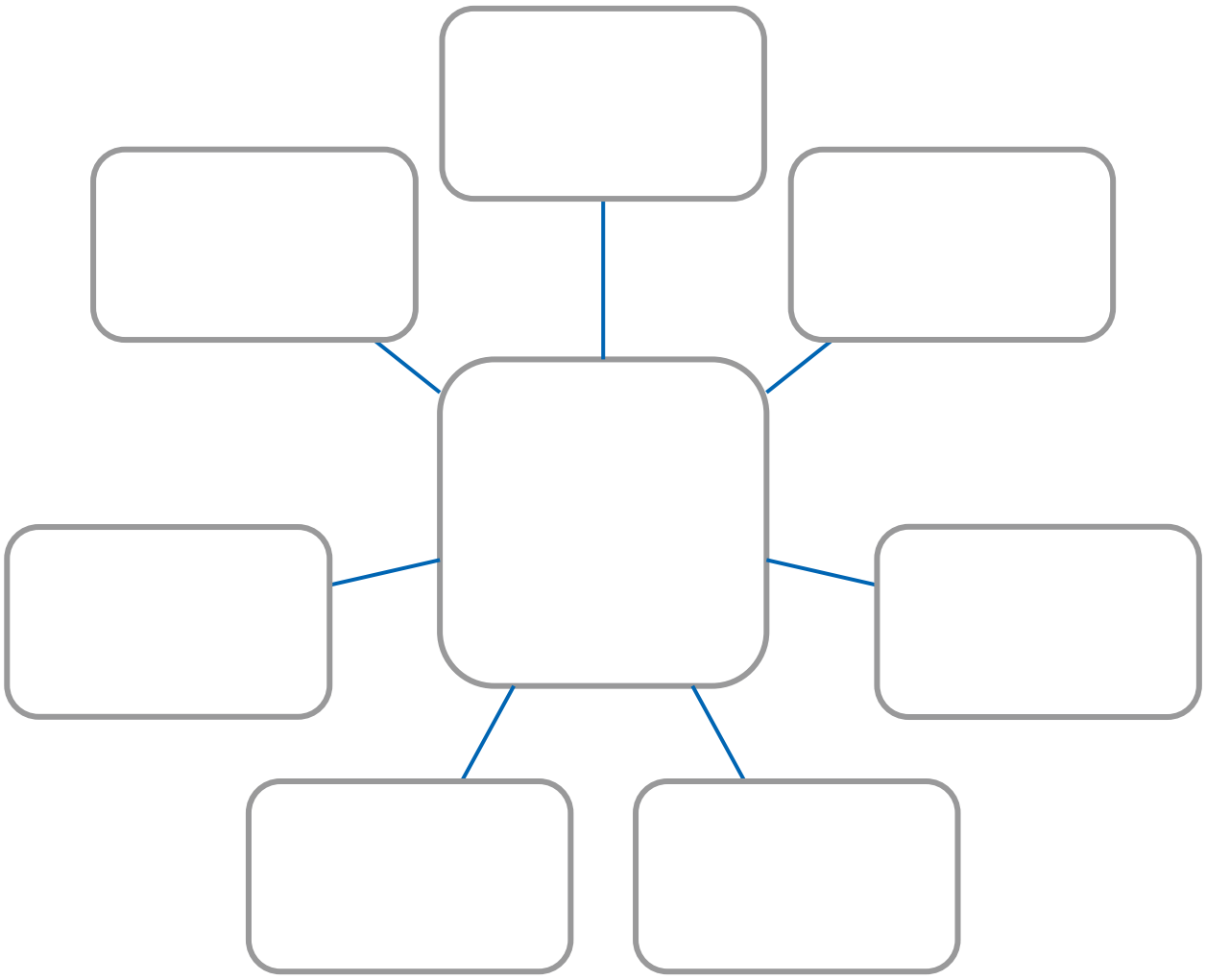
HINT: Remember, someone else is going to have to play your game. Make sure to test it for difficulty, playability, and fun!

Game Design Process

Unit 9: New Game Challenge

DESIGN THE GAME:

Use the template below or create your own mind map to brainstorm the questions you will need to ask yourself or others to develop your game.



Make a list of resources and materials that can be used to make your game field and elements.

Available Resources for Game Field:	Available Resources for Game Elements:	Resources We Need to Find:

Check resources off the lists as they are assembled or found.

Create a rough sketch of the game field you would like to create.

Make sure to label components and materials used so that you can ensure you have everything you need and identify items that might need to be found to complete your game.

Double check the game criteria to make sure you've included all the requirements elements of the game.

Notes about the sketch or design:

Now think about how players will play the game and how they will win.

Describe the game's goal, rules, scoring and any additional details that will affect how the players play the game.

What will be the most challenging aspects of game play?

What will be the least challenging aspects of game play?

What problems do you expect to encounter when playing the game?

Propose a solution for each challenge you anticipate.

Expected Problem:	Proposed solution:

MAKE A PLAN:

Use the template below or make your own timeline or checklist to complete the new game you have designed.

Task	Resources Needed	Estimated Completion Date	Team Members Responsible

TEST THE GAME:

Make a list of things that work well in the game:

Make a list of things that need improvement in the game

As problems with the game are solved, cross them off the list.

REFLECT ON THE GAME DESIGN EXPERIENCE:

How well does the game meet the criteria outlined in the challenge?

The game meets some of the criteria in a limited way.	The game meets at least half of the criteria.	The game meets all required criteria.	The game meets all required criteria and includes additional innovative elements.
Comments:			

How effective were the instructions for the game?

They did not work well.	They worked ok. There were some problems with them.	They worked well.	They worked better than we expected.
Comments:			

How successful was the game play?

The game too difficult (or too easy) to play or there were too many problems. It did not go well.	Some aspects of game play went well but there were many problems.	Overall the game play went well.	Game play went better than expected.
Comments:			

How would you describe your participation in the game design?

I did not contribute very many ideas and did not really participate in the construction of the game.	I contributed a few ideas to game design or I helped to construct the game.	I contributed both ideas and construction effort to game design.	I took a leadership role or contributed innovative ideas to game design and construction efforts.
Comments:			

What would you incorporate into future game design?

What wouldn't you incorporate into future game design?

Describe one important lesson you have learned from this experience.

Describe next steps you would like to explore because of this experience.

Game Design - Rubric

Unit 9: New Game

	Emerging	Developing	Proficient	Advanced
Makes connections between available resources and potential game play.	Identifies some available resources to incorporate into game design.	Identifies some available resources and makes comments about how they can be incorporated into game design.	Creates a detailed list of available resources and clearly describes how they can be incorporated into game design.	Demonstrates an innovative approach to resource acquisition or use in a detailed list of available resources, and clearly describes how they can be incorporated into game design.
Asks and answers questions about game scenario and criteria.	Asks superficial or irrelevant questions about the game scenario and criteria.	Asks meaningful questions about the game scenario and criteria.	Asks meaningful questions about the game scenario and criteria and makes an effort to answer them.	Asks meaningful questions about the game scenario and criteria and uses innovative resources and approaches to answer them.
Describes and represents ideas for game design.	Provides minimal documentation of ideas for game design.	Provides general description and some visual representation of ideas for game design.	Provides a detailed description and visual representation of ideas for game design.	Uses novel tools or an innovative process to describe and visually represent ideas for game design.
Integrates concepts and ideas from previous units into game design or presentation.	Does not mention or refer to concepts or ideas from previous units.	Refers to general concepts or ideas from previous units.	Identifies ways in which concepts or ideas from previous units have influenced game design.	Identifies ways in which concepts or ideas from previous units have influenced specific aspects of game design.

Planning and Documentation - Rubric

Unit 9: New Game

	Emerging	Developing	Proficient	Advanced
Effectively identifies tasks and subtasks required to complete game design.	Identifies general tasks required to complete game design.	Identifies specific tasks required to complete game design.	Identifies specific tasks and subtasks required to complete game design.	Identifies specific tasks and subtasks required to complete game design and effectively communicates the relationship between them.
Prioritizes tasks and subtasks and manages work flow to complete the final game.	Demonstrates an effort to prioritize tasks or estimate completion time to complete the final game.	Prioritizes some tasks effectively and provides an estimate of completion time for some of them.	Prioritizes most tasks effectively and provides an estimate of completion time for all of them.	Prioritizes tasks effectively and provides substantiated estimates of completion time.
Documents key questions, notes, and observations throughout the game development process.	Makes minimal notes or observations throughout the game development process.	Documents key questions, notes, or observations sporadically throughout the game development process.	Consistently documents key questions, notes, and observations throughout the game development process.	Asks insightful questions and consistently makes detailed notes and observations throughout the game development process.

Implementation and Reflection - Rubric

Unit 9: New Game

	Emerging	Developing	Proficient	Advanced
Provides detailed and effective instructions for game play.	Provides incomplete or unclear instructions for game play.	Provides complete instructions for game play that are at times difficult to follow	Provides complete instructions for game play that are generally easy to follow	Provides detailed, complete instructions for game play that demonstrate anticipation of challenges or questions players might have.
Identifies strengths and challenges of the game designed.	Identifies some strengths or challenges of the game designed.	Identifies some strengths and challenges of the game designed.	Identifies and describes both strengths and challenges of the game designed.	Identifies and describes both strengths and challenges of the game designed, and provides solutions or next steps where appropriate.
Draws conclusions about the overall game design experience and identifies personally relevant actions or next steps for the future.	Makes general comments about the overall game design experience.	Makes general comments about the overall game design experience and how it relates to them personally.	Identifies key lessons learned throughout the game design experience and relates these experiences to personal actions or next steps.	Identifies key lessons learned throughout the game design experience, relates these experiences to personal actions, and describes detailed next steps.