FIRST® Robotics Engineering Explorations

Student Guide — Welcome to *FIRST*®

Unit 1

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Activity 1: Robotics Engineering Explorations

Driving Questions

- How do we prepare for *FIRST*® competitions using robots?
- What are the Core Values and philosophies of *FIRST*?
- Why are we working in teams?

What Will I Be Doing?

- I will learn about *FIRST*.
- I will learn about the six Core Values of *FIRST*.
- I will learn about *Gracious Professionalism*® and *Coopertition*®.
- I will practice working with my team to accomplish a shared goal.
- I will link the *FIRST* Core Values to 21st-century workplaces.

Getting Started

- Think about the videos that your teacher presented. Teams competing in *FIRST* accomplish a lot during the year, and the robots they build for competition can do some amazing things!
- Before teams ever get to a competition, they spend a lot of time working on *Gracious Professionalism* and *Coopertition*.
  - *Gracious Professionalism* can mean many things to different people, but, at its core, it means treating everyone respectfully.
    - You help others overcome struggles and challenges.
    - You are responsible and act appropriately.
    - You participate in your team to ensure you do your best.
  - *Coopertition* combines competing against other teams while cooperating with them to solve problems and overcome obstacles.

FIRST CORE VALUES	
Discovery: We explore new skills and ideas. **Innovation**: We use creativity and persistence to solve problems. **Impact**: We apply what we learn to improve our world.	**Inclusion**: We respect each other and embrace our differences. **Teamwork**: We are stronger when we work together. **Fun**: We enjoy and celebrate what we do!

- Think about what you've seen in the videos and what you already know about *FIRST*.
  - Why do you think Gracious Professionalism and Coopertition are important?
  - Why do you think the *FIRST* Core Values are important?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Record the *FIRST* Core Values and your definition of *Gracious Professionalism* and *Coopertition*. Discuss how a team can use these during their competition season.

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, sandwich size bags, tape, string, paper, and objects or weights).

HOW WILL I DO IT?

- Now that you've been introduced to *FIRST* Core Values and philosophies, it's time to put them to use!
- You will work with your team to complete some challenges and think about 21st century workplaces where the Core Values and philosophies of *FIRST* would be used.
- You will be taking notes in your Engineering Notebook. In the next activity, you will learn more about using Engineering Notebooks effectively and why they are essential.

Task 1: Desert Island Dilemma

IDENTIFY THE PROBLEM:

- Your team has been stranded on a desert island surrounded by shark-infested waters. You spot a bag of supplies floating in the water and need to find a way to retrieve the bag without leaving the safety of your island.

DESIGN AND PROTOTYPE:

- Use only these materials to solve the problem: tape, string, paper, and any other simple materials you can find around the classroom.

BRAINSTORM AND EXPLORE:

- Brainstorm and record a method for retrieving your bag in your Engineering Notebook.

DESIGN AND PROTOTYPE:

- You will need to stay in the island area marked by your teacher while you work to bring the bag of supplies to your team.
- Try to use the *FIRST* Core Values of *Gracious Professionalism* and *Coopertition* as you work.

Task 2: Link to the Future

BRAINSTORM AND EXPLORE:

- Teamwork helped you move an object across the room. Skills like teamwork are used by all sorts of professionals across the world. Teamwork is an essential part of any workplace.
- Think about a modern car company. Car companies are large businesses that need to create hundreds of thousands of cars every year. Each year, the company must design and create new models of their vehicles. How would teamwork help a car manufacturing company create the best possible products?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- How many people are involved in creating a new car from start to finish?
- What would the first step be?
- How many people would be involved in that first step?
- How many steps are there between having an idea for a new car and having that car ready for sale?
- What other sorts of 21st-century workplaces would use teamwork?

Career Connections Questions

A restaurant's kitchen can be chaotic. Kitchens need a team of people to create a menu, take orders, cook, and serve food. If the chef, sous chefs, line cooks, and servers don't work together, customers might not get what they order!

Task 3: The Importance of Support

DESIGN AND PROTOTYPE:

- Look at a desk or table in your classroom. How much weight do you think it can hold?
- To create a product that lasts, a group of engineers works together to design, build, and test different versions of desks or tables until they make one that can hold as much weight as possible.
- When people use teamwork, they can create amazing things.

TEST AND IMPROVE:

- Your teacher has given your team some paper and tape.
- As a team, work together to design and build a table supporting as much weight as possible.
- Before you start building, take time for every team member to share their ideas. When you work to solve a problem, the more ideas you can brainstorm, the better the chances are of finding a great solution.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Create a sketch of the table your team built.
- Record how much weight your table could support before it collapsed.

Reflection

- Think about the *FIRST* Core Values:
  - What are they?
  - How do they help teams succeed in *FIRST* competitions?
- Think about the *FIRST* philosophies:
  - What are they?
  - How do they help teams succeed in *FIRST* competitions?
- Was your team able to complete all the tasks?
- Does your team work well together?

Checkpoint

In your Engineering Notebook:

- Record the *FIRST* Core Values and philosophies.
- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 2: Engineers Rock

Driving Questions

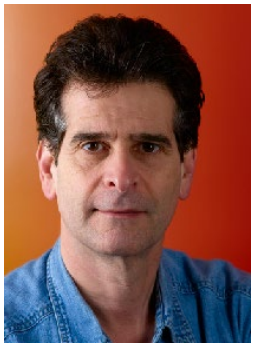
- What are engineers? What do they do? How do they do it? Why are they important?
- What is the purpose of an Engineering Notebook?
- How can we use the Engineering Design Process to solve a problem?

What Will I Be Doing?

- I will learn about engineers and:
  - The different types of engineers.
  - Products made by engineers.
  - The importance of engineers in the 21st century.
- I will learn about the Engineering Notebook.
  - How do I use it?
  - Why is it important?
  - What should I record in it?
- I will learn about the Engineering Design Process.
  - What are the steps in the Engineering Design Process?
  - What is the purpose of each step, and why are they important?
- I will use the Engineering Design Process to create a zip line that moves a ball from one place to another.

Getting Started

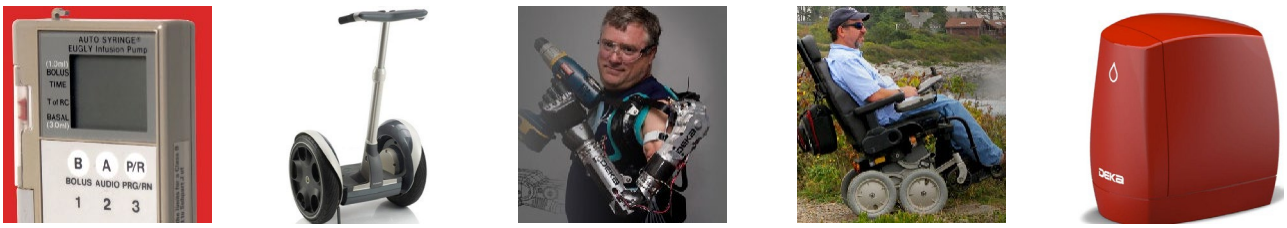
- Look around you. Do you see windows? Computers? Desks? Clothing? Lights? Whatever you see is not there by accident. Someone, likely an engineer, thought long and hard about what you see and use all around you. From the simplicity of a pencil's length to the complexity of a microprocessor, engineers are responsible for it all!
- Let's look at an inventor who has been changing the world. From addressing the world's water crisis to founding one of the most successful programs for students, the sky is truly the limit for engineer and inventor Dean Kamen.



Dean Kamen

DID YOU KNOW?

- These are just some of the amazing inventions Dean Kamen can be credited with:
  - The nonprofit youth robotics program, *FIRST*
  - The first wearable insulin pump for diabetics
  - The Segway scooter
  - The advanced prosthetic called the LUKE™ Arm
  - The IBOT® all-terrain electric wheelchair
  - A non-polluting, low-power water purification system



Some of Dean Kamen's inventions. From left to right: AutoSyringe, Segway scooter, LUKE™ Arm, IBOT® wheelchair, Slingshot water purifier. Images taken from http://www.dekaresearch.com/innovations

- Engineers like Dean Kamen use Engineering Notebooks to document their ideas and work.
- These notebooks help engineers keep all their ideas in one place. In the real world, this is very important because if engineers want to patent their work, they must have proof that their ideas were their own if their claim to the invention is ever questioned.
  - Think about the videos you've watched in this section.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Record a few examples of different types of engineers.
  - What sorts of projects would each type of engineer work on?
  - Would they use an Engineering Notebook? Why might they use it?
- Could engineers use the *FIRST* Core Values and philosophies to improve the products they design? How?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, building materials for your zip line from your teacher).

HOW WILL I DO IT?

- You will investigate some real-world examples of Engineering Notebooks and learn what kinds of information you should be recording as you go.
- You will learn about the Engineering Design Process engineers use while working on a project.
- You will decide on a classroom challenge to utilize the Engineering Design Process and record your process in your Engineering Notebook.
- You will apply the Engineering Design Process and make a zip line to move a Ping-Pong ball from one place to another.

Task 1: A Notebook of Your Own

IDENTIFY THE PROBLEM:

- Engineering is not easy. Even the best ideas sometimes don't work right away. Keeping a great Engineering Notebook is essential because it will allow you to look back on all your ideas and designs, and that strange idea you had three weeks ago or a year ago might be the perfect solution to the problem you are trying to solve today. Keep your ideas. Big or small, each one is important!
- One of the coolest things about the Engineering Notebook is that it can be designed and utilized in a way that works best for *YOU*. For instance, do you want to fill your notebook with sketches? Great! What about jotting down your thoughts? Sure! Pictures? No problem! The Engineering Notebook is your chance to be even more creative as you explore what it is like to be an engineer.

DESIGN AND PROTOTYPE:

- Look at some examples of real Engineering Notebooks. Discuss what you see.
  - What do you feel is essential in an Engineering Notebook?
  - Why will Engineering Notebooks be necessary for your team as you work through activities?
  - How can you ensure you are using teamwork while recording information in your Engineering Notebook?

Task 2: Find a Problem, Design a Solution

IDENTIFY THE PROBLEM:

- You have explored and discussed the fields engineers work in as they tackle real-world problems. Now, you and your team will take your discussions and implement your ideas! All engineers, no matter what field they work in, use a problem-solving process to help them design solutions to problems around them.
- The Engineering Design Process is made up of the following series of steps. Notice that they relate to the *FIRST* Core Values.

Identify the Problem

- Before you can create things to help a community, you need to understand the community you are working to improve. (Inclusion)
- Not everyone sees the world in the same way. To create meaningful change, it is essential to remember that everyone's experience is different. (Discovery)
- If you want to learn, asking questions is the best way to start.
- Try viewing a problem from a different perspective. (Discovery)

- Who does the problem affect? How does it affect them? Where and when does the problem take place? Why is the problem occurring?

Brainstorm and Explore

- Finding the perfect solution for a problem rarely happens right away. The more ideas you can generate, the more material you have to pull from to create a solution. (Innovation)
- Think about all the people affected by the problem you are focused on. How would they approach the issue? (Inclusion)
- Use your imagination; inspire your team to go beyond obvious solutions. (Teamwork)

Design and Prototype

- Take your team's ideas and turn them into something you can touch. You don't have to build a perfect robot immediately; you may want to draw an outline or write a storyboard.
- Don't try to build the perfect solution right away; start small.
- When you've created something you think would help address the issue, build multiple copies to keep improving your work.

Test and Improve

- Put what you've built into the community you are working with.
- Test what you've built to learn more about the problem you are trying to solve and improve your design.
- You might find that what you've built doesn't solve the problem like you wanted. Learning from failures is an essential part of the Engineering Design Process, and it's an opportunity to improve your design further.

- Some of the steps to the Engineering Design Process have connections to Core Values listed beside them above. Can you connect the other steps in the Engineering Design Process and the *FIRST* Core Values? Write the connections you make in your Engineering Notebooks.
- When you build your robot in upcoming units, you will work with more aspects of the Engineering Design Process that are closely tied to your goals. Some of those steps include system-level design, detailed design, test and verification, and robot production.

BRAINSTORM AND EXPLORE:

- Think of a problem that you encountered in a classroom at school. The problem should be something that all your team members can relate to. Use the first three steps of the Engineering Design Process to design a solution to your identified problem.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Record the steps of the Engineering Design Process.
- Describe the problem your team has decided to address using the Engineering Design Process.
- Record how you used the first two steps of the Engineering Design Process to create a solution for the problem you selected.

Task 3: Zip, Zap, Zop

IDENTIFY THE PROBLEM:

- In this task, you will work in pairs to develop a fast and effective design while keeping Core Values in mind. (If you have an uneven number of people in your team, form groups of three.)
  - You and your teammate must design and build a basket carrying a Ping-Pong ball from the top of a zip line to the bottom.
  - Constraints:
    - It must take 3 seconds or less for the basket to travel from the top to bottom.
    - Your zip line must be at least 6 inches long.
    - You can use only tape, straws, lightweight cardboard (the back of your notebook, for instance), fishing line, marbles, pipe cleaners, and paper cups for the basket.

BRAINSTORM AND EXPLORE:

- Explore your materials and brainstorm ideas about using how to use the materials to carry the ball.

DESIGN AND PROTOTYPE:

- Each team member should be part of the design and construction of your zip line. Remember, it is okay if your first idea doesn't work. Work together, use *Gracious Professionalism*, and never give up!
- Test and Improve:

- When you've completed the last step in the Engineering Design Process, go back and see if there are any improvements you can make to your zip line.
  - Go slower! Zooming along quickly is a lot simpler than slowing down. Can you make your object take longer than 10 seconds to get from top to bottom?
  - More is more! Can you create a basket that will carry two or more balls in 3 seconds or less?
  - Launch it! Can you think of a way to get the ball out of the basket and into the air?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What was challenging about designing your solution?
- Was there anything you could not figure out?
- How did you deal with problems you couldn't solve?
- Sketch your zip line and label the materials you used.

Reflection

- What type of engineer do you find the most interesting?
- How did you use the *FIRST* Core Values while you were working with the Engineering Design Process?
- How could the Engineering Design Process help solve problems in your local community?
- What parts of this activity did you find difficult? Why?
- What can you improve the next time you work with the steps in the Engineering Design Process?

Checkpoint

In your Engineering Notebook:

- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 3: Problems and Innovation

Driving Questions

- Why is identifying a problem an important part of the Engineering Design Process?
- What are some problems our community has faced in the past, and how were they solved?
- What is a problem our community is currently facing?

What Will I Be Doing?

- I will learn how essential innovations can change the world.
- I will research our community and define a problem that affects the quality of people's lives.
- I will research our community to identify problems it has faced in the past.
- I will learn about innovations that have changed my community and how they did it.

Getting Started

- It's easy to take some basic everyday innovations for granted, but without those innovations, the world would be very different.
- One of the most important innovations ever made is the wheel. Think about all the things that a wheel is used for and imagine the world before the wheel was around! People have been building off past generations' innovations since the invention of the wheel. Now, we have complex robots and machines to help us work, build, and assemble.
- Innovations are often the result of people trying to solve problems in their community. To solve a problem their community is facing, a person must first identify the problem and understand the details that affect the problem. The first step in the Engineering Design Process has engineers think through a problem. Before you can invent a robot to solve problems, you must know what the problem is.
  - Consider a few examples of problems that could have inspired the invention of the wheel.
  - Think of another simple innovation that is used every day. What problem do you think first inspired people to invent it?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils).

HOW WILL I DO IT?

- You will investigate another example of a simple innovation that changed the world.
- You will research your community to find a problem that affects community members' lives.
- You will research your community to learn about its past problems and the innovations that helped it get to where it is today.

Task 1: Who Needs Nails?

IDENTIFY THE PROBLEM:

- What can you use to connect two things to help construct a house, put a table together, or hang a picture on a wall? A long time ago, people had this same dilemma. Someone produced a nail as the solution to this problem. A nail is a simple tool, but our lives would be very different without it. Think of the room around you or the building you are in. All these structures use nails to join building materials together.

BRAINSTORM AND EXPLORE:

- What sort of problem inspired people to create their first nails? Brainstorm some ideas for situations where materials people may have used before nails wouldn't have been enough to combine two things.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What sort of materials would nails have been first used on?
- What materials did people need to create nails?
- What wouldn't we be able to build today without nails?

- What innovation could be used to join things together if we hadn't created nails?

Task 2: Modern Problems

IDENTIFY THE PROBLEM:

- Before you can innovate and invent solutions, you need to find a problem. All communities have problems, and they can range from minor to very serious. You can usually identify a problem by trying to understand the experiences of different groups of people in a community. Not all community problems are obvious; sometimes, it takes time and effort to identify an issue.
- Think about some of the groups of people in your community and try to identify with their unique experiences. The problems they face might be something you've experienced, or they could be something you've never considered before.

BRAINSTORM AND EXPLORE:

- Your teacher has prepared some resources to help you research your community. Remember, the problems a community faces may not be apparent right away. An excellent place to start when you want to understand a group of people is to ask questions. You can use the following questions to guide your investigation into your community:
  - What are the basic needs for people to survive? Are those needs being met?
  - How do you make sure people feel safe?
  - Are there areas in your community where people struggle more than others? Why?
  - What do people in your community need that other communities might not?
  - Can you separate your community into different groups of people?
    - Is sorting people into different groups a good idea?
    - What are some benefits of sorting people into groups?
    - What are some dangers of sorting people into groups?
  - Are there members of your community that are at more of a disadvantage than others? Why?
  - What are some environmental factors that might be affecting your community?
  - Are green spaces important to your community? Why?
- Try to make sure you are using as much detail as possible when describing a community problem. In the upcoming activities, you will use the Engineering Design Process to attempt to solve your problem, so make sure the issue you focus on is something an engineer could address.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What is the problem you identified?
- What questions did you ask when trying to identify a community problem?
- What were the answers to those questions?
- What groups of people are affected by the problem you've discovered?

Task 3: Problems of a Bygone Age

IDENTIFY THE PROBLEM:

- All communities start somewhere. Before a community can reach its full potential, there are usually some problems that need solving. The older a community is, the more likely they have used innovation to get to where they are today. If a community began a long time ago, it is essential to consider how that community started and where the people came from. Newer communities have the advantage of modern technology, but that doesn't mean they haven't faced their own problems. Understanding the sorts of innovations used in a community's past can be helpful when thinking about what it took for a community to get to where it is today.

BRAINSTORM AND EXPLORE:

- Your teacher has prepared resources to help you research your community's past. Look back into your community's history and try to find some innovations that helped get it to where it is today.
- The following questions can help guide your investigation:
  - When was your community founded?
  - Why did people decide to settle in your community?
  - Where did the people who first settled in your community come from? How did they get from there to here?
  - How were the first buildings in your community built?
    - Who built them?
    - Why were those specific buildings built first?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What questions did you ask while searching for innovations important to your community? What answers did you find?
- What innovations were important in the development of your community?

Reflection

- Can you explain the importance of simple innovations to the modern world?
- Did you find information about your community that you didn't know?
- Can you verify the information you discovered about your community using another source?
- Do you have enough information about innovations from your community's past to explain their importance?
- Do you have enough information about the community problem you identified to use the Engineering Design Process in later activities?

Checkpoint

IN YOUR ENGINEERING NOTEBOOK:

- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 4: Solve Your Own Problem

Driving Questions

- Are there robots in our community right now?
- Can we use a robot to solve the community problem we identified?
- What would a robot need to do to solve our community problem?

What Will I Be Doing?

- I will identify robots that are helping with my community's needs.
- I will discuss what a robot needs to do to solve my community problem.
- I will use the four steps of the Engineering Design Process to design and build a robot prototype.
- I will reflect on how my robot should function to solve our community problem best.
- I will create a plan for future iterations that could help my team bring our design to life to impact the community.

Getting Started

- In the last activity, you looked at how a problem or need in a community can lead to an innovation that changes the world. A straightforward example of such an innovation would be the wheel or the nail. A more complex example is Gutenberg's printing press.
  - Johannes Gutenberg created a mechanical device that pressed an inked metal plate with moveable letters into paper to print text. The plates enabled printers to move around letters.
  - Moveable type printing had been invented in China almost 400 years before, but because of the complexity of the Chinese alphabet, it didn't catch on as quickly.
  - Before Gutenberg's plates, a printer would need a plate for each page of a book they wanted to print.
  - The metal plate design that Gutenberg invented meant printers needed only one plate and an assortment of letters.
  - The speed of Gutenberg's press made it so books could be distributed to more people than ever before. As books became more available, more people were able to learn to read.
  - Gutenberg didn't invent the printing press, but he found a way to innovate and solve a problem that he saw needed solving.
- To solve your community problem, you don't need to waste a lot of time for no reason. Everyone has an idea of what a robot looks like in their head. The most basic definition of a robot is a machine that can perform a task automatically. Some robots are controlled remotely by a human, and some run automatically off a set of instructions. By the end of the course, you will be able to build a robot that can compete in a game you design as a group. You will develop the details of your game in the next activity, but you can get an idea of what *FIRST* robot games involve by watching the introduction video for games for previous seasons.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- After watching the video for last year's challenge, think about what might be the most difficult part of building a robot. Why do you think that is?
- How do you think your team will use the *FIRST* Core Values and philosophies while you are competing in a robot challenge at the end of the course?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, cardboard, toothpicks, rubber bands, tape, glue, notes on your community problem from the last activity).

HOW WILL I DO IT?

- In the last activity, you researched innovations from your community's past.
  - Try to keep those innovations in mind when you consider your robot's design.
  - Think about the research you did in the last activity and discuss robotic solutions your community could use to fulfill its needs.
  - The robot you design will need to solve the problem you've identified, but you can draw from robots your community might already be using.

Task 1: Where Is the Closest Robot?

BRAINSTORM AND EXPLORE:

- When designing a robot, you don't need to start from nothing. Just like Gutenberg, all the best innovators build upon past innovations. You've investigated your community and have an idea of its basic needs and the innovations used to meet them. Robots are used to perform tasks worldwide; some might be at work in your area already!
- Review the notes you took during the last activity and consider the innovations used to meet your community's needs. Focus on some of the problems that people have already solved.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Are any problems you discovered in your community solved using a machine?
  - Are the machines automated?
  - What sort of tasks do they perform?
  - Would a person be able to perform the same job?
- What is the difference between a machine and a robot?
- If you can't find any robots being used in your community, can you think of how robots could be used in the future?
- What do you think is the most common use of robots? Why?

Task 2: A Robot of Your Own

BRAINSTORM AND EXPLORE:

- You've researched, identified problems, and thought about innovation; it's time to design your robot! The information you've been keeping in your Engineering Notebook will be very important for this task, so check your notes. The community problem you've identified could be solved in a few different ways, so there is more than one way to design your robot. You've already begun working with the first two steps of the Engineering Design Process during your research, so it is time to move on to Step 3: Design and Prototype!

DESIGN AND PROTOTYPE:

- Review your notes on the community problem you will be addressing and use the Brainstorm and Explore step to begin solving it. It may be helpful to try to break the problem into smaller chunks.
- Answer the following questions in your Engineering Notebook and sketch what you think your robot might look like:
  - What will the robot have to do to solve the problem?
  - How is it going to perform those tasks?
  - What tools will it need to do them?
  - Will the robot run automatically or be controlled remotely?

Task 3: More Than One Problem? No Problem!

IDENTIFY THE PROBLEM:

- In the last activity, you learned that problems are often the spark that leads to innovation.
  - Sometimes the work that an engineer does to solve a problem can also be applied to other problems.
  - When Gutenberg was working on his printing press, he aimed to make printing faster and less expensive.
  - Gutenberg solved the problems he set out to solve while also making books more readily available to the public and increasing the literacy rate across Europe.

DESIGN AND PROTOTYPE:

- Look at the sketch you made of your robot in the last task. During the initial Design and Prototype step of the Engineering Design Process, your team had to consider all the things your robot would need to do to achieve its goal.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- How can you create a model or prototype of your community robot to illustrate your design idea to others?
- What other knowledge might you need about robots to develop your prototype further?
- What other knowledge and materials might you need to test your prototype as an actual robot?
- Create a need-to-know list of things you might want to learn to develop this prototype further.
- As you learn more about robots, you can continue to develop your ideas and prototype.

Reflection

- Why would robots be used to solve community problems?
- Is a robot the simplest solution to the community problem that you identified?
- What tools do your community robot and a robot competing in a game from a previous season have in common?
- Was your team able to use the *FIRST* Core Values and philosophies while you were brainstorming ideas for your robot's design?

Checkpoint

In your Engineering Notebook:

- Record responses to the questions in the Getting Started section of the activity.
- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 5: Help Wanted, Positions Available

Driving Questions

- How do we know if we've successfully used the Engineering Design Process?
- What sorts of skills do we need for big design and engineering projects?
- What professions are needed for big engineering design projects?

What Will I Be Doing?

- I will look at an engineering design project and consider the skills needed to complete it.
- I will explore ways to decide whether a design project is successful.
- I will connect the skills required to complete an engineering design project with professions and trades that specialize in those skills.
- I will apply what I've learned to my team's community problem.

Getting Started

- You have used the Engineering Design Process in the past few activities to solve problems and build solutions. How have you measured your success when you've used the Engineering Design Process? In a game scenario, you can tell if you've been successful by seeing if you've met the winning conditions for that game. If you are playing tic-tac-toe, you know you've won when you've lined up three X's or O's. Think of a few examples of games you enjoy playing and try to answer the following questions:
  - What are the winning conditions for the games you picked?
  - Do you need to do more than one thing to win?
  - How do you know if you've lost?
- When using the Engineering Design Process in previous activities, you needed to use various skills. Look back on the notes you took on the Engineering Design Process in your Engineering Notebook:
  - Which *FIRST* Core Values or philosophies are essential to the different steps in the Engineering Design Process?
  - What skills are helpful in the Engineering Design Process?
  - How do you know when you've used the Engineering Design Process successfully?
- Think of a real-world engineering or design project such as cars, robots, rockets, video games, or software.
- When you've decided on a real-world example, break the project's creation down into the Engineering Design Process steps.
- When design teams in the real world decide to work on a project, they need to then recruit people with the skills needed to carry out the Engineering Design Process successfully.
- Discuss the following questions with your team using the real-world project example you selected. You can use the Internet to research a specific project for more information.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- How would the team that worked on the project know if they were successful in their design?
- What skills would the team need to complete the project?
- What professions specialize in the skills required to complete the project?
- What types of jobs are involved in the different steps of the project?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, a device with Internet access).

HOW WILL I DO IT?

- Applying the different steps of the Engineering Design Process in the real world requires real-world skills. In this activity, you will look at what jobs would be involved in a complex project like designing and constructing a functional skyscraper!
  - Outline the Engineering Design Process for a company building a skyscraper. Be sure to discuss a method for deciding if the project was successful.
  - Research the different professions involved in the Engineering Design Process for building a skyscraper.

Task 1: The Foundations of a Skyscraper

IDENTIFY THE PROBLEM:

- Your team oversees a company that designs and constructs buildings in major cities. You've recently received a new contract and will build a new skyscraper. Your team has been given a piece of land downtown, and you need to guide the project from start to finish. Some businesses are looking to set up offices in your building and have given you money for the project. They want you to design and build a skyscraper that people from all over the world will travel to see. Designing and building a skyscraper is a big project, and your team must ensure you hire the right people for the job.

BRAINSTORM AND EXPLORE:

- Before you start thinking about hiring people, break the project down using the Engineering Design Process and record the steps in your Engineering Notebook. When you've broken the project into steps, use the following questions to help you think about the different professionals you would need to hire for the project and what they would be doing. Use your available resources to research the questions if you need help.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- How will you manage your money?
  - Who would oversee setting a budget?
  - How will they ensure the project stays on budget?
  - How will they know if they've been successful?
- How will you decide what the building will look like?
  - Who will design the building?
  - Who will decide on the materials you need for the building?
  - What goals will they try to achieve, and how will they know if they've been successful?
- Who is going to construct your building?
  - What different skills are involved in putting a building together?
  - Will the people creating the structure for your building also install the windows and elevators?
  - What goals will the people building your skyscraper try to achieve, and how will they know if they've been successful?

Task 2: Phase Two

BRAINSTORM AND EXPLORE:

- Your team has decided on how you will figure out a budget, design your skyscraper, and begin construction, but you are not done yet! To ensure your clients are happy, your team needs to ensure that the building you're constructing is finished before people start moving in. You also want to ensure your skyscraper looks impressive, so try to be creative.
- Think about what the ideal skyscraper will look like when you walk in.
  - What will the lobby look like?
  - How will you get between the floors?
  - What will each floor need?
  - Will all the floors look the same?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Who is going to ensure the inside of your building looks great and meets the needs of the companies moving in? How is it going to perform those tasks?
  - What sort of skills are involved with making a space look nice?
  - Who will install floors, paint walls, and ensure everything is put together?
- How will you ensure all the people working on your skyscraper are working as a team?
  - Is communication between the various professionals working on your building important? Why?
  - What would happen if the different professionals working on your building were unaware of each other's work?
  - Who will oversee communication between the different groups of people working on your building, and what skills would that person need?
  - What goals would a person in charge of communication need to set? How will they know if they've been successful?

Task 3: The Right Person for the Job

IDENTIFY THE PROBLEM:

- Your hired professionals have now finished your skyscraper project, and it's time to apply what you've learned to your community problem.
- Review your notes in your Engineering Notebook and think about the different skills you will need to complete the project. Remember the *FIRST* Core Values and philosophies as you think about what you need to do to complete the robot that will solve your community problem.

BRAINSTORM AND EXPLORE:

- Take turns sharing your strongest skills with your team. As a team, decide on a role for each member. Not everyone can oversee building a robot or managing your funds, so work together as you pick roles.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What aspects of the Engineering Design Process will your role help with?
- What skills do you have that make you well-suited for your role?
- What goals does your role need to achieve? How do you know if you've completed your goals?
- How will you ensure you follow the *FIRST* Core Values and philosophies while in your role?
- What will you need to communicate with your teammates in your role? How will you do it?

Reflection

- When you were investigating the roles involved in the Engineering Design Process, did any of the jobs or professions surprise you? Why?
- What do you think are the five most important skills required by the Engineering Design Process?
- In this activity, you needed to reflect on the notes you took in your Engineering Notebook. Did you have any trouble finding the notes you were looking for? If you did, how could you change how you use your Engineering Notebook to make finding notes easier?
- Why is communication an essential part of the Engineering Design Process?

Checkpoint

In your Engineering Notebook:

- Record your answers from the Getting Started section of the activity.
- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 6: Safety and the Kit

Driving Questions

- What do we need to know so we can stay safe while working with our robot?
- What will we use to build the robot?
- What is in the robotics kit?

What Will I Be Doing?

- I will learn about some of the safety hazards engineers must be aware of.
- I will learn about the rules I need to follow to stay safe while working with my robotics kit.
- I will open my robotics kit and identify some parts I will work with.

Getting Started

- What is the most important thing engineers need to know when they begin a project?
  - The Engineering Design Process is certainly important.
  - Being able to work with your engineering team is essential.
  - Before you start a project, you need to ensure that you and your team are safe.
- There are lots of different safety models that people use depending on the industry they work in.
  - In school science labs, teachers and students should know how to keep themselves safe and what to do if something breaks or goes wrong.
  - One method for keeping a workplace safe is the use of rules like those set by the Occupational Safety and Health Administration (OSHA).
  - OSHA creates rules for labeling chemicals, lays out procedures for accidents in a lab environment, and sets safety standards for work environments.
- Have you ever heard of animatronics? Animatronics are machines that are used to make objects seem lifelike.
  - Animatronics can be very big, like some of the practical effects of dinosaurs or aliens built for scenes in big-budget movies.
  - Animatronic machines can also be small, like a rubber fish toy singing songs.
- Imagine your team has been recruited to work on an animatronic robot for an upcoming movie. The type of movie is up to you. You might be building a big, friendly animal for a kid's movie or a terrifying monster for a new horror flick.
  - What will your robot look like? What will it do?
  - What dangers would you need to know about if you were working with a giant animatronic machine?
  - What sort of safety precautions would your team need to take while you work with your animatronic creation?
  - If your animatronic creation started moving around without warning, would the safety procedures you generated keep your team safe?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, robotics kit with its list of materials).

HOW WILL I DO IT?

- After reviewing the *FIRST* Safety Manual, you will consider some tips for keeping yourself safe while working with the robotics kit. When you know how to stay safe, you can move on to opening your kit and identifying some of the pieces you will use to build your robot.
- After you open your kit, you will:
  - Search for some of the pieces you will need.
  - Sketch the pieces you will use.
  - Think about what some of the pieces might be used for.

TASK 1: SAFETY SLOGANS

Identify the Problem:

- A clear set of rules is crucial when it comes to safety. Some rules are obvious, such as:
  - Don't run.
  - Unplug power sources before working on electrical components.
  - Always wear safety glasses.
- Before you can explore the tools and materials you will be working with, it is very important that you understand and respect the rules for safely designing, building, and programming, no matter where you happen to be.
- Like OSHA, *FIRST* has a set of guidelines to ensure everyone stays safe while working with robots. Did you know that *FIRST* holds a competition inviting teams to create videos about staying safe while working on robots? Take some time to watch some of the entries from previous years: *FIRST* Robotics Competition Safety Awards.

Brainstorm and Explore:

- To help your team and the rest of the class remember important safety tips, your team will need to create five safety slogans. Think about the student-created videos and consider the following questions:
  - What did the videos have in common?
  - Did the videos miss anything important?
- If you have trouble thinking of slogans, here are a few examples:
  - Don't break a hip! Clean spills before you slip!
  - Fess up if you mess up!
- When you've decided on your five slogans, have one of your team members share a few of your favorites with the class.
  - Record your slogans in your Engineering Notebooks.

Task 2: The Kit

IDENTIFY THE PROBLEM:

- Before you turn a design idea into a reality, you must ensure you have suitable materials for the job. When designing a skyscraper in the last activity, you needed to think of what resources you had available before you could start.
- If you oversaw the construction of a rocket, you would need to know what you had to work with. Engineers and technicians who create complex machines need to know what they will have available before they can start a project. As you explore some of the different parts in your kit, think about how they could be used in a robot.

BRAINSTORM AND EXPLORE:

- Now, it's time to explore the robotics kit. You might be familiar with items such as sprockets, gears, and servos. Or, you might not know a sprocket from an axle, and that's okay! This is your time to examine each piece and get a feel for the materials you will be working with.
- You and your team will be going on a kit scavenger hunt! In the spirit of *Coopertition*, see if your team can finish first! Don't worry if you don't finish first, though, because no time spent exploring the kit is wasted!

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- What part sends and receives electrical signals and acts as the robot's brain?
- What do gears look like? Draw a picture of one.
- What components hold other parts together? Draw a picture of one.
- What parts are used to build the structure of your robot?
- What do the parts that connect structure pieces look like? Draw a picture of one.
- What parts in the kit will help the robot move?
- What parts in the kit convert electrical energy from the battery to rotational movement?

When you've finished the scavenger hunt, record your results in your Engineering Notebook:

- Was your team able to finish the scavenger hunt before any of the other teams?
- Did you have trouble locating any of the parts?
- Were you familiar with any of the parts you found?
- Where have you seen the parts you were familiar with used?

Task 3: Check Your Kit

IDENTIFY THE PROBLEM:

- An essential part of being safe is exploring the materials and tools you will work with. It is not just about what you have and how you use it. When you are finished with a project and are ready to put your supplies away for the next project, how you store your materials and what you do if something is broken or missing is just as important.
- You've identified some of the parts of the kit that you will be working with in the coming activities, but there are many pieces you haven't looked at yet. You will work with all the parts in your kit as you build your robot for the course, so it is a good idea to ensure all the parts are where they should be.

DESIGN AND PROTOTYPE:

- Your kit comes with a list of the included parts.
  - As a team, take out all the parts of your kit and ensure you have everything on your list.
  - If you are missing any parts, let your teacher know.
- Before you put the parts of your kit away, think of a way to organize your pieces to make them easy to find. While working on a way to organize the pieces, think about ways to keep your team safe while working with your kit.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Which parts do you think you will use the most often?
- Which parts did you have difficulty finding during the scavenger hunt? Why?
- How can you ensure your team hasn't broken any pieces while you work?
- How can your team ensure all the pieces of your kit are put away after you finish using them?
- What would your team do if you broke a part while you were working?
- Are there any pieces in your kit that you must be careful with? Why?
- How can you ensure you are safe while working with that piece?
- What should you do if a team member is injured while working with the kit?

Make sure you record your method for organizing your kit and why it is used in your Engineering Notebooks.

- When you've found a way to organize your parts and repack your kit, use the tape and markers your teacher provided to label your kit with your team's name and a few of the safety slogans you produced in Task 1. Be creative and make your kit stand out!

Reflection

- How can your team keep everyone safe while working with the kit?
- What should you do if there's an accident and a team member is hurt?
- Think about your robot.
  - What could you do to make sure the robot is safe to use?
  - What parts of your robot might be dangerous?
  - What could you do to ensure your robot is not a safety hazard when it is operating?
- Why is having an organized kit essential?

Checkpoint

In your Engineering Notebook:

- Record your answers to the questions from the Getting Started section of the activity.
- Record your responses to the Engineering Notebook prompts in Tasks 1-3.
- Record your responses to the reflection questions.

Activity 7: Ball Game

Driving Questions

- How can we design our own ball game?
- How can we work with another team as an alliance to win a game?
- How can we use the *FIRST* Core Values, *Gracious Professionalism*, and *Coopertition* while we work to win a game?

What Will I Be Doing?

- I will create some rules and methods for scoring points in a ball game and share them with the rest of the class.
- I will use the Engineering Design Process to design a ball game field that incorporates the materials available in the class.
- I will present my game design to the class.
- I will work with the class to choose a ball game competition to work toward competing in throughout the course.

Getting Started

- There are a few things that all *FIRST* games have in common.
  - Before the game, each team is paired with another team to form an alliance.
  - During the game, each alliance's robots compete against another alliance to score points.
  - The alliance a team works with in one game may compete against them in a later game.
  - Every game has a playing field, a time limit, a period where the robots move autonomously, a period where robots are controlled by a remote, and an endgame period with additional scoring methods.
- Look at a one-page game description from a previous *FIRST* season for ways to score points.
  - Working with others is an integral part of *FIRST*, so it is important to remember the Core Values and the philosophies of *Gracious Professionalism* and *Coopertition*.
  - During the final game, a referee will ensure both alliances follow the rules. If an alliance breaks a rule during the game, the opposing alliance is awarded points, so ensure you know the rules and stick to them!
- We all have watched or played ball games such as baseball, basketball, or soccer. *FIRST* competitions are designed after sporting events and ball games such as these, except *FIRST* involves alliances of teams that encourage competition with *Coopertition*.
- How can you use *Gracious Professionalism* and *Coopertition* while you are competing in a game?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens and pencils, ball, robotics kit, one-page game description for a game from a previous season).

HOW WILL I DO IT?

- In this activity, you will work with your class to create a set of rules for a new ball game.
- Your team will design a game field using the Engineering Design Process.
- You will pair with another team to create an alliance and work together to combine your two designs.
- You and your alliance will present your design to the class.
- The class will vote on a final competition design.

Task 1: Our Game, Our Rules

IDENTIFY THE PROBLEM:

- Before you can play a game, you must know the rules.
  - The game you will create during this activity needs to have some structure so that you know what it needs to be and how it will be played.
  - You need to know how to score points.
  - In the spirit of *Gracious Professionalism* and *Coopertition*, you will work as a class to create a set of rules for all alliances to play by.
  - Before you start, look at the one-page game description for some games from a previous *FIRST* season for inspiration.

BRAINSTORM AND EXPLORE:

- Brainstorm a few ideas for rules and methods for scoring points on your own before you discuss the game as a class.
- To make sure the game you are designing is like a *FIRST* competition, consider the following questions:
  - How big should the playing field be?
  - Will the game have a time limit? What should it be?
  - How will you score points?
  - Will you have possibilities different game strategies (offensive and defensive)?
  - Will there be practice rounds before teams compete?
  - What are the penalties for breaking the rules?
  - Who will watch the teams to ensure everyone follows the rules?
- Discuss the game with your class when you have a few examples of rules and ways to score points. If you are having trouble agreeing on what the game should look like, take a vote.
- Remember to keep *Gracious Professionalism* and *Coopertition* in mind while working out the rules of the game. You are all in this together!
- Record an outline of the game you've designed as a class in your Engineering Notebook.

Task 2: The Competition Field

DESIGN AND PROTOTYPE:

- You know the rules, so it's time to make a competitive field!
- Think of the game's rules as a problem and the field you will be building as an innovative solution.
- Design, build, and test your game field using the Engineering Design Process. You want to ensure that all the parts of your game field operate how you want them to.
- Remember, you will be integrating your field with another team's design.

TEST AND IMPROVE:

- Get a ball and determine the field playing area in your classroom.
- Look at the available materials and consider how they could fit together to form a ball game.
- Ask your teacher if there are other supplies in the room you could use besides the ball to create your ball game.
- You can begin testing your design when you've finished the Design and Brainstorm steps from the Engineering Design Process. Use classmates to act out the robot's actions, like moving the ball from one place to another. Consider the timing of an autonomous period, driver-controlled period, and endgame, if you are incorporating them into the rules. What are the different scoring options available?

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Sketch the ball game you've designed with all the materials labeled.
- Record why you used these materials.
- Record what aspects of the design you found easy and what you found challenging.
- Record what problems you ran into while you were testing your ball game.

Career Connections Questions

- In an engineering project, engineers must ensure they have someone in charge of the materials that compose their design.
- The person in charge of gathering materials is often referred to as the head of procurement.

Task 3: Alliances

IDENTIFY THE PROBLEM:

- Many games in *FIRST* pair teams into alliances that work together as they compete. Being in an alliance comes with all sorts of advantages.
- Having another team to work with means you can combine the skills and abilities of two teams.
- In a ball game, the other team in your alliance will probably have a robot that looks different than yours. The more variety you have in the tools and parts you use, the more you can do!

- Ensure that safety is a priority while playing the game. In the future, you will be playing with robots, so ensure that there isn't person-to-person contact as part of the game.

DESIGN AND PROTOTYPE:

- Form an alliance with another team.
- Remember that your allied team for one game might be your opposition later.
- Take some time to look at the other team's design and answer the following questions in your Engineering Notebook:
  - How is their ball game different from yours?
  - How is their ball game like yours?
  - What do you think the most challenging part of joining the two ball games will be?
- When you understand the other team's design, combine your two designs into one ball game.
- When you've successfully connected your designs, sketch the combined ball game in your Engineering Notebook.

Task 4: Game Time

TEST AND IMPROVE:

- It's time to test your ball in a human competition against another alliance! Find another alliance in your class and challenge them to a game.
  - Before you compete, make sure the ball game your alliance has built works how you want it to.
  - Find an area where you and your opponent have room to set up, and make sure you have all your materials ready.
  - In the final ball game with robots, a volunteer or teacher will likely act as the referee. For this game, ensure you have at least one member of your alliance acting as a referee and another team member recording points scored, time elapsed, and other needed information.
- When you and the opposing alliance are ready, start the game! Depending on the rules you created at the start of the activity, you might play more than one round.
- After you have completed your testing, take some time with the opposing alliance to reflect on the game.
- As you finish playing your game with your alliance, your teacher will ask you to share your game with the class. You then will conduct a class brainstorming session to determine the final elements of the game that your class will compete in.

IN YOUR ENGINEERING NOTEBOOK, DOCUMENT AND ANSWER THE FOLLOWING PROMPTS:

- Who won the game? By how many points?
- What winning strategy was best suited to the game?
- Are there any game rules you would change now that you have played?
- Should you make any changes to your ball game after seeing the opposing alliance's design in action?
- Did you learn anything about the Engineering Design Process while playing the game?

Reflection

- Could you have improved the game created as a class? How?
- How can you apply what you learned in this activity to your community problem?
- What was the most challenging part of designing a ball game?
- What was the most enjoyable part of designing a ball game?
- Why are *Gracious Professionalism* and *Coopertition* important parts of competing in *FIRST* games?

Checkpoint

In your Engineering Notebook:

- Document what you learned from the examples of past *FIRST* games.
- Reflect on how you can use *Gracious Professionalism* and *Coopertition* while you compete in a game.
- Outline the rules for the game you've decided on as a class.
- Record your responses to the Engineering Notebook prompts in Tasks 1-4.