FIRST® Robotics Engineering Explorations

Student Guide — Build a Bot

Unit 2

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Activity 1: A Robot Skeleton

Driving Questions

- What is a frame?
- What is a chassis?
- How do we build a frame from the parts in our robotics kit?
- How will the chassis design help our team compete in the ball game?

What Will I Be Doing?

- I will learn about the purpose of a chassis.
- I will build a frame using parts from the robotics kit and examine the parts needed for a chassis.
- I will explore modifications to the chassis to help the robot be more successful in the ball game.

Getting Started

- In the last unit, your team was in charge of building a skyscraper for other businesses to use. To thank you for your fantastic work, one of those companies has invited your team into their office to look at their latest invention: the time machine! After assuring you that their machine has been tested and is safe to use, the company offers to send you back in time. After your team files into the time machine together, you are transported back to the ancient world, where the wheel was recently discovered!
- You've arrived in a farming town just in time for the summer harvest. As you walk around the town, a nervous-looking farmer approaches you. The farmer explains that they need help moving their produce from their farm to the market. It has been a good year for these farmers, and they have a lot of produce to transport. This farmer's fields are outside of town, and he needs to find a way to move the harvest to the town center market as quickly as possible.
- You have access to some wood, two wheels, nails, and a hammer. The simplest solution to the farmer's problem would be building and using a cart. Your team needs to design a structure, or frame, to mount the wheels on.

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

- Consider how to design a frame for your cart.
  - To turn a frame into a vehicle, you first need to add parts that will enable you to mount attachments like the wheels. A frame with parts for mounting vehicle pieces is called a chassis. A chassis is like the skeleton of a vehicle, and it can come in all shapes and sizes depending on the job they are designed to do.
- Think about the purpose of the cart you will create for the farmer and answer the following questions in your Engineering Notebook:
  - How can you ensure your design is strong enough to carry a heavy load of produce?
  - What parts should you add to your frame to make it into a chassis?
  - When you've decided on a chassis for the farmer, sketch out your design and label the materials you will use.

WHAT'S NEXT?

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

HOW WILL I DO IT?

- You will discuss where you've seen chassis used before and investigate the importance of a chassis by brainstorming with your team.
- You will research different chassis types to learn how they are made.
- You will investigate methods for using a chassis to solve your ball game.
- You will put together a basic frame using parts from your robotics kit.

Task 1: Chassis Knowledge

IDENTIFY THE PROBLEM:

- Think about the last four-wheeled vehicle you saw. You might be thinking about a typical car, a bus, or a truck, but all vehicles have one thing in common: they start as chassis.
- Robot frames are made from various materials, and each one will have a chassis suited to its specific purpose.
- When you design a cart to move a farmer's harvest to the market, you must consider moving as much food as possible. Cars and trucks are also designed with specific purposes, and their chassis are created to serve them.
- Most vehicles, like cars and trucks, use a four-wheel chassis for stability and optimal control. Motorcycles use a two-wheel chassis for their designs, and 18-wheeler tractor trailers use a chassis that supports 18 wheels! Some modern motorcycles are even built using a three-wheel chassis.

BRAINSTORM AND EXPLORE:

- In your Engineering Notebook, make a chart with three columns and label them "What We Know," "What We Want to Know," and "What We Learned" from left to right.
- In the first column, list five facts about chassis you know to be true.
- Under "What We Want to Know," come up with five questions you want to answer.
- As a group, use the Internet to research different types of chassis and try to answer the questions to put into your chart. Record what you've learned in the final column when you finish your research.

WHAT WE KNOW	WHAT WE WANT TO KNOW	WHAT WE LEARNED

Example chart for organizing your chassis knowledge

Task 2: A Chassis for the Ball Game

IDENTIFY THE PROBLEM:

- Now that you know chassis and their purpose, it's time to apply that knowledge to your ball game. Review your notes on the Engineering Design Process for solving your ball game as a team. A robot's chassis is one of its most essential elements. The shape and size of a robot's chassis define what the finished robot will look like and what it can do.

DESIGN AND PROTOTYPE:

- Using what you've learned from your research on chassis, design a chassis that would help you solve your ball game. Think about the way that car and truck chassis are assembled.
- answer the following questions in your Engineering Notebook:
  - How will your chassis help your robot support all the parts necessary to complete its job?
  - If your robot needs to carry heavy loads, how can you design your chassis to ensure it doesn't bend or break?
  - What size does your robot need to be to do its job?
  - What parts in your robotics kit would you use to create a chassis for your ball game?
- Sketch a chassis for your ball game robot in your notebook and label the parts you would use. List any tools you would need to assemble the chassis.

Task 3: Robo-bones

BRAINSTORM AND EXPLORE:

- Before you build your robot's chassis, you need to build its frame. While a chassis includes parts for mounting wheels, motors, batteries, and more, its frame is simply the bones of the machine. In the robotics kit scavenger hunt in Unit 1, you were introduced to some essential parts you will use to build your robot. To create a frame, you need only a few parts.
- Make sure everyone has a role to play when you are working with your robotics kit; not everyone will be able to build simultaneously. Assign a team member to organize parts or take notes. A great way to practice *Gracious Professionalism*® is by ensuring everyone can contribute.

DESIGN AND PROTOTYPE:

- To build your initial chassis frame, you will need structural elements, brackets, and other fasteners to connect the structural elements. The way you build your chassis is entirely up to you, but you might want to start by finding a way to join structural beams at right angles.
- After you've finished your frame, sketch it in your notebook and label the parts you've used.

Reflection

- Think about your chassis research from Task 1.
  - Why are chassis important? What do you need to know about your robot when designing its chassis?
- Think about the tasks needed for your robot to score in the ball game.
  - What parts of your ball game do you need to consider when creating your robot chassis?
  - How is your robot's chassis different than its frame?
- How can you ensure you are using teamwork and *Gracious Professionalism* when working with your robot?

Checkpoint

In your Engineering Notebook:

- Record your responses to the prompts 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.

Cleanup Tips

Ensure all the parts you used during the activity are returned to your kit.
If your chassis is staying assembled, ask your teacher where to place it

Activity 2: Get Your Chassis Moving

Driving Questions

- Why are different wheels used for different jobs?
- How do we mount wheels to our chassis using the robotics kit?
- What sorts of wheel configurations can you create from the robotics kit?

What Will I Be Doing?

- I will look at different types of wheels and learn how their purpose affects their design.
- I will learn how to design a chassis and mount wheels using the parts in my kit.
- I will build and test two different wheel configurations and investigate the pros and cons of each arrangement.

Getting Started

- In the last activity, your team designed a cart frame for transporting a farmer's crops to market and investigated the difference between a frame and a chassis. While frames and chassis are essential to a vehicle design, they are only the first piece of the vehicle. The chassis you investigated were all designed with parts for mounting wheels. In this activity, you will use your parts kit to design and build a chassis and then mount wheels to your design.
- When you designed the cart for the farmer, you were in a world that had only recently been introduced to wheels. The only materials you had available for your cart were wood and some nails, so the wheels on your cart would have been very simple.
- Talk to your team about the wheels your cart would have used:
  - What do you think the wheels would have looked like?
  - How would you have built a wheel using the simple materials you had?
  - Can you think of any problems you would encounter using simple wooden wheels?
- Today, we can make wheels out of all sorts of materials. The cars you see on the road use rubber tires on metal rims, but the shape and size of the wheels on a car are very different than those on a bus or semitruck. Sometimes, the same vehicle will use different types of wheels depending on the vehicle's purpose. Sometimes, a vehicle will use different tires depending on the season.
- Research some of the different types of wheels that vehicles use today and answer the following questions in your Engineering Notebook:
  - What is the difference between a car's wheels and the wheels on a tractor?
  - What are the wheels on a plane's landing gear made of? Why?
  - What is the difference between a car wheel and its tires?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, robotics kit).
- Assign roles for the activity:
  - Who will oversee the kit organization? Who will assemble the parts? Who will take notes?

HOW WILL I DO IT?

- Now that you know about some of the different types of wheels in use today, you will look at the wheels you have in your kit, investigate their design, and discuss how you could use them in your ball game robot.
- You will identify the parts you need to mount wheels, find them in your kit, and then design two chassis configurations that use the wheels in your kit.
- After you've designed your chassis, you will test the two different wheel configurations and investigate the pros and cons of each configuration.

Task 1: Different Wheels for Different Jobs

IDENTIFY THE PROBLEM:

- In the last unit, you identified at least one set of wheels in your robotics kit.
- You probably noticed that some of these wheels look quite different from those on the road. Instead of a tire, the wheel might have a ball of rollers around its perimeter.

- What do you think the purpose of different wheel designs is? While the wheels look different, they get mounted onto your chassis in similar ways.
- Before you can put your wheels onto a chassis, you need to understand the purpose of the wheels in your kit and identify the parts you will use to mount them.

DESIGN AND PROTOTYPE:

- Open your kit and find parts that can be used for movement, such as wheels or rollers. Unlike modern cars that use four of the same kind of wheels, the robot you use will have two different pairs. Look at both types of wheels.
- Sketch both wheel types in your Engineering Notebook and then answer the following questions:
  - What is the purpose of rubber on a wheel?
  - What is the purpose of other types of rollers or non-tread wheels?
- Research your kit of parts and determine if there are suggested ways to mount wheels. Each type of wheel has an engineering design behind it. Many manufacturers have suggestions and published guides for mounting wheels. Your teacher can help you find documentation to refer to.

Task 2: Where Do My Wheels Go?

IDENTIFY THE PROBLEM:

- Your robotics kit likely contains different types of wheels. Standard wheel types used on robots are rollers, omni, tread, grip, and mecanum wheels. The specific wheels you have will depend on the robot kit you are using.
- There are many ways to mount wheels onto your chassis. While considering how to mount your wheels to your chassis, think about which wheels should be attached to your motors and why. Research the types of wheels that you have in your kit and how they work. Wheels such as omni wheels and mecanum wheels offer unique capabilities for your robot.
- Most cars and trucks have two wheels in the front and two in the back. While designing your robot, think about what it needs to do. Many robots have different wheel configurations, and you might have build guides available for your kit.

DESIGN AND PROTOTYPE:

- There are many ways to design frames and chassis and even more ways to configure the wheels on a chassis. Use the Engineering Design Process to design a chassis to mount your wheels. Decide where to mount which wheels. Sketch your design in your Engineering Notebook and label all the parts and wheel types on your chassis.
- When you have completed your sketch, answer the following questions in your Engineering Notebook:
  - What are the benefits of having three wheels instead of four?
  - How did you decide where to mount your wheels?
  - Did you encounter any challenges while you were designing your two chassis?
  - Which of your two designs would better solve your ball game? Why?

Task 3: From Brainstorming to Building

DESIGN AND PROTOTYPE:

- You may learn something new each time you work through the Engineering Design Process. Building will be easier as you become more familiar with your available parts. For now, use the parts you identified in Task 1 to turn your chassis designs into a reality.
- Using your sketches as a guide, gather all the necessary parts and assemble your chassis.

TEST AND IMPROVE:

- Test your first wheel configuration by putting it on the ground and pushing it. If you need to change the design of your chassis after seeing it roll, record the changes you make in your Engineering Notebook and explain why you decided to make them.
- When you are happy with how your first design moves, remove the wheels and assemble your second wheel configuration.
- Repeat the test you did with your first chassis. If you need to make changes to improve the way your chassis moves, record the changes you make in your Engineering Notebook and explain why you made them.
- When you are happy with how your chassis moves, return any parts you are not using in your kit, but keep the chassis together. Put your chassis and kit of parts away and answer the following questions in your Engineering Notebook:
  - Did you have to change your chassis after you performed the roll test?
  - Did you encounter any challenges as you were building your chassis? What were they?
  - What can you do in the future to avoid the challenges you encountered?
  - Now that you've tested your chassis, which design is better suited to the ball game? Why?

Reflection

- How does the purpose of a wheel affect its design?
- What is the difference between a wheel and a tire, and why would a car change its tires depending on the season?
- When you designed your ball game robot, did it use wheels?
- If your ball game robot used wheels, what type of wheels did it use? Why?

Checkpoint

In your Engineering Notebook:

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

Cleanup Tips

Ensure all the parts you used during the activity are returned to your kit.
Keep the chassis you've left assembled with your kit of parts.

Activity 3: Mounting Motors

Driving Questions

- How will the robot move?
- How do we mount motors onto the chassis?
- Where should we mount motors on the chassis?

What Will I Be Doing?

- I will investigate the parts added to a chassis that make a vehicle move.
- I will examine the different motors I have available in my robotics kit.
- I will find a way to mount motors onto my chassis.
- I will decide where my motors should be placed on my chassis and mount them.

Getting Started

- During your time machine adventure, you designed a cart that a person or animal would have used to move a heavy load. We've come a long way since ancient times and now have many methods for moving wheels without relying on living things for power. The chassis you designed in the last activity was able to move when you pushed it, but when it comes to solving your ball game, you want a robot that can move on its own.
- Before you make your chassis move, think about what you would need to add to a vehicle chassis to get it going.
- Cars use engines to move around. There are many engine types, and they can be used in many ways. How would an engine be attached to a traditional car chassis? What parts of the car would it be connected to, and how does it stay in place?
- Take time with your team to research how an engine is mounted to a chassis. Then, investigate how engines make the vehicle's wheels move forward and backward.
- When designing your robot, how did you imagine it would move? What would propel it forward and backward? Using what you've learned in your research, answer the following questions in your Engineering Notebook:
  - Will your robot have an engine or a motor?
  - How would your robot's motor be attached to its frame?
  - How would your robot's motor make your robot's wheels move?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, robotics kit, tools for building, safety equipment, chassis you built in the last activity, device with access the Internet).
- Assign roles for the activity (builders, documenters, researchers, and so on).

HOW WILL I DO IT?

- Your robot will use motors to turn its wheels. Most modern car engines use combustion to get moving, but your motors will use electricity drawn from a battery.
- You will find the motors and mounting parts in your kit, decide where to mount the motors, and determine which wheels to attach. Then, you will attach your motors to your chassis and wheels.

Task 1: The Right Motor for the Job

IDENTIFY THE PROBLEM:

- Your kit has a few parts that turn electricity into movement. To move your wheels, you must use motors with enough power to move your whole chassis. You will also want to use motors that give you the most control over your robot. Your kit comes with different types of motors. Understanding motor types is essential. You wouldn't want to choose a motor that is too fast without enough torque or too slow with too much torque for the chassis. Your teacher can provide you with resources for researching your motors.

DESIGN AND PROTOTYPE:

- Locate the motors in your kit. Using your previous research, determine the best method to mount the motors to your robot. Use the kit manufacturer's instructions to identify which parts you will need.
- When you finished collecting all the parts needed to mount your motors, discuss the following questions with your team and record your answers in your Engineering Notebook:
  - Are your motors like any of the motors you came across in your research?
    - If they are, what motors are they like?
  - What characteristics do they have in common?
  - What parts do you need to mount the motors onto your chassis?
  - How might overtightening or under-tightening a gearbox affect the motor?

Task 2: Where Should My Motors Go?

BRAINSTORM AND EXPLORE:

- Motors are one of the most essential parts of your robot; without them, your robot won't go anywhere. When you mounted your wheels in the last activity, you had not yet seen the motors, so your team might need to adjust your chassis design to accommodate the motors' size.
- Before you mount your motors, think about how they will transfer motion to your wheels, which wheels they will transfer motion to, and how they will be secured. Discuss with your team where your motors should be placed on your chassis.

DESIGN AND PROTOTYPE:

- Before you mount your motors, decide where they should go. The placement of your motors is essential for two reasons: they are heavy and will affect the balance of your robot, and they will drive a set of your wheels forward, so they shouldn't be rubbing against any other parts. Take some time placing your motors on your chassis before you attach them. Think about which wheels will be attached to which motors.
- Create two sketches of your chassis with motor placements in your Engineering Notebook.

Task 3: Motor Up

DESIGN AND PROTOTYPE:

- When you have an idea of where your motors should be mounted, you must first ensure you have room for them. The motors you use might affect the design of your chassis.
- Look at the motor configurations you sketched in the previous task and think about which configuration would give you the most control over your robot when you power it up. Think about the weight of your motors and ensure the design you sketched includes all the parts you need to keep your motors attached to your chassis and your wheels attached to the motor's axles.

TEST AND IMPROVE:

- Use the parts you gathered in Task 1 to mount your motors onto your chassis. When your motors have been mounted, attach a wheel to each one and sketch their configuration on your chassis in your Engineering Notebook.

Caution

Many motor designs require proper mounting with the correct bolts in the right spot to prevent damage. Refer to your robot's manufacturer resources to determine the mounting instructions. Failure to do so could void any warranty a motor might have if it is damaged.

Reflection

- Are your motors secured to your chassis?
- Are your wheels secured to your motors?
- How might the motor's speed and torque affect your robot's ability to perform in the ball game?

Checkpoint

In your Engineering Notebook:

- Record answers to the questions from the Getting Started section.
- Record your answers to the questions in Task 1.
- Record your answers to the reflection questions.
- Sketch your chassis after you mount your motors.

Clean Up Tips

Follow the procedures outlined by your teacher or facilitator for cleaning up and storing your materials. Be sure to address each of these questions as you clean up:

1. Did we inventory our pieces to make sure nothing was missing or broken?
2. Did we store our notes and Engineering Notebooks in a designated spot?
3. Did we store our built pieces in the proper location?
4. Have we reported any broken or missing pieces to the teacher or facilitator?

Activity 4: Power and Control

Driving Questions

- How do we power our robot?
- What is a control system and what does it do?
- How do we connect all the electronic components of my robot?

What Will I Be Doing?

- I will learn about vehicles that use electricity to power their motors.
- I will investigate wiring diagrams.
- I will attach the battery from my kit of parts to my robot chassis.
- I will attach my control system to my robot chassis.
- I will use wires to connect my motors to my control system and battery.

Getting Started

- Have you ever wondered how an electric car works? Most vehicles you see on the road today use combustion engines that run on either gasoline or diesel fuel. In the last activity, you saw how engines are mounted into car chassis and what combustion engines look like. In traditional cars, fuel is loaded into a tank that is pumped into the engine. Engines are connected to the driver's pedals so the driver can control the amount of fuel being sent, which determines how fast the car will go. In electric vehicles, however, the process is slightly different.
- In an electric car, a battery provides power to an electric motor. Unlike a gas- or diesel-powered car that has pedals connected directly to the engine, electric vehicles link the driver's pedals to a controller. The controller determines how much power the car's battery sends to the motor at any given time.
- Think about the way your ball game robot will move around.
  - Is your robot's power source connected directly to its motors?
  - How will your robot know how much power it should send to its motors?
- But how are all the internal parts of an electric car connected? In a gas-powered vehicle, the fuel tank and engine are connected by pipes and pumps, but in an electric vehicle, everything relates to wiring.
- Electricians and electrical engineers use wires to move electricity from a power source to where it is needed. Wires can be used for simple tasks like plugging a phone into a wall to charge, or they can be used to run electricity through an entire building. When people are working on electrical projects, they usually use wiring diagrams. A wiring diagram is like a map outlining all the wires in an electrical system. Your teacher will supply a wiring diagram for a motor controller commonly used in robots. Answer the following questions in your Engineering Notebook:
  - What do you think the first example schematic represents? What symbols are present?
  - What does the functional block diagram's schematic represent?
  - What symbols are present in it?
  - How is an electrical current flow controlled for a DC motor?
  - How could you use a wiring diagram to improve your ball game?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, robotics kit, assembled chassis, wiring diagram examples).

HOW WILL I DO IT?

- Like an electric car, the robot you are building uses a controller connecting the battery to the motor. Your kit has a control system that will function as the controller for your robot. You will connect your battery and control system to your robot and learn how to combine all the electronic components using wires.

Task 1: The Source of Your Power

IDENTIFY THE PROBLEM:

- Like an electric car, your robot will use a battery to power its motors. If you haven't charged your battery yet, plug it in after you finish this activity; you will need a fully charged battery when you begin the next activity. Determine how your robot gets power; where will the battery be placed? Discuss with your teacher where the battery is and what the process will be for keeping it charged.

DESIGN AND PROTOTYPE:

- Using the resources provided by your teacher for your robotics kit, create mounts for your battery, robot controller, and motor controllers. These items are all part of the control system. They control how electrical signals are sent from the battery to the motors. Different robots might have this system condensed and close together, like in a computer, or they may all be separated or spread out.
- Find or create a mounting device for the battery. Some manufacturers have pre-built battery holders. If yours does not, you will need to design one from your kit of parts.
- Your battery holder design should meet the following guidelines:
  - Securely keep the battery in place, so if the robot tips over, the battery will not fall.
  - Have no pinch points that could damage the battery, or the wires connected to it.
  - Have a mount for the power switch that is protected yet easily accessible.
- Sketch your battery mount in your Engineering Notebook and include where it will be placed on the robot.
- Mount the battery according to your design.
- When your battery is securely mounted, in your Engineering Notebook, sketch the chassis, label the battery, and explain why you chose this placement. Describe any challenges you had in designing and building your battery mount.

Task 2: The Controller

IDENTIFY THE PROBLEM:

- In an electric car, a controller takes commands from the driver and sends them to the motors. In your robot, the controller processes all the information sent to your robot; you can think of it as your robot's brain. In Unit 3, you will learn how to send commands to your robot.
- The controller is probably the most critical part of your robot, so securing it to your chassis is essential.

DESIGN AND PROTOTYPE:

- It's important to consider wire placement when mounting a control system. Where will the wires run out of each controller port? What path will they need to take to get to the motors? Consider the orientation or direction in which you are mounting the control system.
- When you have decided where to mount your control system, connect it to your chassis with the needed mounting and fastening parts.
- When you have securely mounted your control system to your chassis, discuss the importance of a controller in an electric vehicle with your team.

Caution

Most control systems are sensitive to electrostatic discharge. They should not be mounted directly on metal.

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

- Why are the inputs of an electric car not plugged directly into its motor?
- Create a quick sketch of your chassis after you've mounted your control system.
- How does the orientation of the control system matter? Did you have to make any modifications or changes as you mounted it?

Tips

- When you are connecting wires, make sure the cables do not bend at sharp angles; sharp angles can cause damage to the wire. Use tools such as clips or hook-and-loop fasteners to help you manage your wires without kinks.
- Try to leave some slack in the wire. Moving parts could disconnect tight wires.
- When all your wires are connected, draw a simple wiring diagram that shows which port each motor is connected to in your Engineering Notebook. When you begin programming your robot, you will need to know what is plugged into each port.

Task 3: All the Wires

IDENTIFY THE PROBLEM:

- The wiring in a robot is like an electronic nervous system. If you were building a house, an electrician would need to run wires through the walls so people could turn the lights on and off.
- In a robot, the wires don't just send power; they also carry information. The wires from your robotic kit are usually meant to connect the motor to the control system.
- Larger robot systems, such as a *FIRST*® Robotics Competition robot, will have a power distribution panel that acts like a circuit breaker box in your house. The wires allow the control system to send power to the motors and let the motors send information back. You will learn about the types of information your motors can send in the next unit.

DESIGN AND PROTOTYPE:

- Use a wiring diagram provided by your parts' manufacturer to determine the correct ports and wiring methods for your robot. Failure to follow wiring guidelines can lead to robot failure and improper operation.
- When your motors are connected to your control system, you should then connect your power switch if it's needed for your system. This switch enables you to toggle the battery power to your system. If your system has a built-in battery, you need to know where its power button is.

Reflection

- Does a wiring diagram help you execute your ball game robot design?
- Were you able to attach the battery and controller to your chassis?
- Was it difficult to attach your control system? If so, why?
- Discuss the path of electricity as it runs through your robot and how it is controlled.

Checkpoint

In your Engineering Notebook:

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

Clean Up Tips

Ensure all loose robot parts are returned to your kit.
Put away your assembled robot, Engineering Notebook, and robotics kit.

Activity 5: Fine-Tuning

Driving Questions

- How can we improve the design of our robot?
- Are all the parts of our robot secure?
- Is our robot ready for programming?

What Will I Be Doing?

- I will learn more about the final steps of the Engineering Design Process.
- I will find ways to improve the way my robot is built.
- I will make changes to my robot, so it is ready for programming.

Getting Started

- So far, you and your team have looked at various engineering projects. From designing a zipline to mapping out all the steps for building a skyscraper, you've used the Engineering Design Process from start to finish a few times. Now that your robot is built, it's time to focus on the last step of the Engineering Design Process: testing and improving your robot.
- Your team has gained a reputation for outstanding design projects. After hearing about your work building chassis, a car manufacturer has asked your team to help them through the Test and Improve step of the Engineering Design Process for a car they've designed. The car designers have created a chassis and attached wheels and a motor. Before they begin mass production, the manufacturer wants your help to ensure the car is as perfect as possible.
- Discuss the Test and Improve step of the Engineering Design Process for a new car. The manufacturer must ensure the car is safe and performs well. As a team, design a few tests that you would want to perform on the car prototype.

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

- What tests will you perform?
- What is the goal of each test?
- Why is each test important to perform?
- How will you know if the car passed each test?
- Why are the steps of the Engineering Design Process important?
- What do you think the most critical test would be? Why?

WHAT'S NEXT?

- Gather your team.
- Gather your supplies (Engineering Notebook, pens or pencils, robotics kit, assembled chassis).

HOW WILL I DO IT?

- To prepare for the next unit, you must ensure your robot is well-built and ready for programming. In this activity, you will review your frame, wheels, motors, battery, and control system. Your team will design some tests to assess your robot and make improvements based on the results. Later, you will add other components to your chassis, so you need to save room for additions.

Task 1: Your Frame

DESIGN AND PROTOTYPE:

- The frame is the first part of your robot that you assembled. Since there are various design options, your team's frame might look very different from the other teams. When you designed your frame, how did you determine its dimensions? Do you think you could improve your robot's performance by changing your frame?

TEST AND IMPROVE:

- Before making any changes to your frame, consider what your robot might do in coming units. You will program your robot to move around, so consider what would happen to your frame if your robot collided with something. Design a test to evaluate your robot's frame. Explain the test in your Engineering Notebook.
- Use the test you designed to evaluate your robot's frame and record the results in your Engineering Notebook. If you need to make changes to your frame, explain why and record a sketch of the new version of your frame.

Task 2: Motors, Wheels, and Gears

DESIGN AND PROTOTYPE:

- Your robot's ability to move around will play a huge role in its performance. As you built your chassis, you thought about the placement of wheels and motors and how they connected. Your wheels, motors, and even gears work together to determine the way your robot moves around.
- To test your robot's motors and wheels, design a test that evaluates how the wheels, motors, and gears work together. Think about which wheels the motors are attached to, the placement of your motors, and the type and number of gears you use when creating your test.

TEST AND IMPROVE:

- Before you change your robot's wheel and motor configuration, think about how you want your robot to move. If your robot needs to move very quickly, consider changing how you've set up your gears. If you are worried about your robot tipping over, you might change the position of your wheels on the chassis.
- Evaluate your robot's wheels, motors, and gears using the test you designed. Explain the test in your Engineering Notebook. You might have one team member perform the test while another records the results.
- If your team decides to change the configuration of your robot's motors, wheels, or gears, sketch your new design and explain in your Engineering Notebook why you made the changes.

Task 3: Controller, Battery, and Wiring

IDENTIFY THE PROBLEM:

- In the last activity, you mounted all your robot's electronic components on your chassis. The control system is a vital part of your robot. If the electrical system and the directions you give it don't communicate properly, your robot won't work. As you think of a way to test your robot's electronic components, think about how a car manufacturer would test their electronic components before they run electricity through them.
- You might run into issues when you move your motors in later activities, but if you test your system's configuration now, you can reduce the chances of problems later.

TEST AND IMPROVE:

- Before you make changes to the electronic components on your robot, design a test to evaluate their placement on your chassis. Remember, the control system will be used to communicate directions to the motors, so the system's hardware needs to be secure.
- A wiring diagram for your system can help ensure that the control system's wiring is efficient. An efficient system prevents loose connections and can make it easy to identify where problems are in the future.
- Review your battery and wiring placement. Consider if they are placed efficiently. Can you tell at a glance where each wire goes?
- Design a test that evaluates the control system on your robot. Record and explain the test you will be performing in your Engineering Notebook.
- Have one team member perform your test while another records the results. After the test, if you've decided to change how your control system components are attached to your chassis, sketch your new design in your Engineering Notebook

Reflection

- What tests will you perform on your ball game robot before you test it in the ball game?
  - What will the tests check for?
  - How will you know if your robot passes the tests?
  - What will you do if your ball game robot fails the tests?
- Why are the steps of the Engineering Design Process important?
- What have you learned about your original design from the tests you performed?
- Did you encounter any obstacles while you were performing your tests?
  - What obstacles did you encounter?
  - How did you deal with them?

Checkpoint

In your Engineering Notebook:

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

Clean Up Tips

Ensure all loose robot parts and materials are returned to your kit.
Put away your assembled robot, Engineering Notebook, and robotics kit.