



Hello and welcome to the FIRST LEGO League Challenge Robot Build Self Guided Training. In this hands-on workshop, you will be guided through the building of a competition-ready robot. This is the first step to turn the pile of LEGO bricks into a scoring robot. I would like to take a moment to thank Louis Rubbo from FIRST Nevada for sharing the materials that this training is adapted from.

# FIRST Indiana Robotics Staff

**Chris Osborne**  
*Vice President of Programs*

**Trisha Thompson**  
*FLL & FTC  
Program Manager*

**Ashley Robbins**  
*President*

**Dan Leathers**  
*Operations*



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Let's start by meeting the FIRST Indiana Robotics Staff. On the left is Chris Osborne, our Vice President of Programs, next is me, Trisha Thompson, I am the FIRST LEGO League and FIRST Tech Challenge Program Manager. I will be your primary contact and source of information. I am here to assist with team growth and support. Then there is Ashley Robbins, our President, and Dan Leathers, our Operations Manager. Dan is responsible for all event-related tasks.

## FIRST Senior Mentors



### What do *FIRST* Senior Mentors do?

- Raise awareness about *FIRST* programs and events in their local community
- Support coaches, mentors, and volunteers
- Provide technical and non-technical support to *FIRST* teams
- Recruit rookie teams
- Help strengthen existing teams and enable year-to-year growth



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We are also fortunate to have two FIRST Senior Mentors in Indiana, Lori Langley and Kyle Heaton. Kyle is an FRC alum, and is highly involved with our FRC program. You may already know Lori, she is a former FLL Coach, and has served as our State Judge Advisor in Indiana. Lori has a wealth of knowledge about FIRST LEGO League, and she is happy to share that with our teams.

# Session Agenda

- Robot Build
  - Introduce the SPIKE Prime robotics platform
  - Build a competition-ready robot

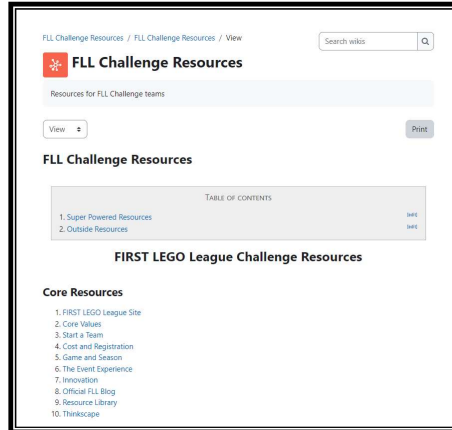


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In this session you will be introduced to the SPIKE Prime robotics platform, and build a competition ready robot. After completing this session, you will want to move on to the Programming Self Guided Training.

# FIRST Indiana Robotics Playbook

<https://playbook.firstindianrobotics.org/>



FLL Challenge Resources / FLL Challenge Resources / View

**FLL Challenge Resources**

Resources for FLL Challenge teams

View

**FLL Challenge Resources**

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**FIRST LEGO League Challenge Resources**

**Core Resources**

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4. Cost and Registration
5. Game and Season
6. The Event Experience
7. Innovation
8. Official FLL Blog
9. Resource Library
10. ThinkScape

Today's presentation, as well as other useful documents can be found in the FIN Playbook.



# Robot Build

## *FIRST LEGO League Challenge Building Platforms*



Benefits of building with  
LEGO Bricks

- Familiarity
- Quick Build, no tools required!
- Robustness



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LEGO bricks offer a number of benefits for teaching STEM and robotics. Because LEGO has been around for generations, you won't need to spend any time introducing LEGO to your students. LEGO bricks offer quick prototyping and disassembling, encouraging students to experiment and make new iterations of their designs.

# Robot Build

## *LEGO SPIKE Prime*



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There are now four generations of a competitive FIRST LEGO League robotics building platforms, RCX, NXT, MINDSTORMS EV3, and the SPIKE Prime. Currently, teams primarily use either the MINDSTORMS EV3 or the SPIKE Prime platform. The EV3 was retired in 2020 and is no longer supported by LEGO Education, but is still frequently used in competitions. This training only covers SPIKE Prime, which is the kit you see pictured here.

# Robot Build

*Open Your Kit!*



Most teams use a combination of the Spike Prime base kit and the Spike Prime Expansion set.



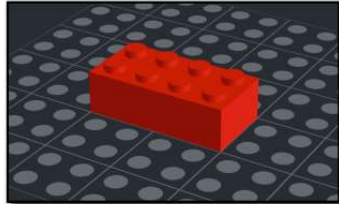
Now you'll want to open up the SPIKE Prime kit and become familiar with the pieces. Most teams use a combination of the SPIKE Prime base kit and the SPIKE Prime Expansion set. You'll find the pieces are distributed in two layers, the upper layer is where the smaller pieces are sorted and is made of two sorting trays, while the lower layer is where the larger pieces are stored.

Inside the SPIKE Prime kit is a large cardboard card that provides a visual list of included LEGO pieces. This card only shows the parts included with the SPIKE Prime base kit, and shows a suggested way to sort the pieces. It's a good idea to follow this so you will be able to quickly find the part you need. On the top-right of the card there is a one-to-one scaled drawing that shows the relative lengths and colors of the included axels. An 11 Module beam is also shown for reference and to demonstrate that axels are measured in lengths that equal the number of holes on a beam.



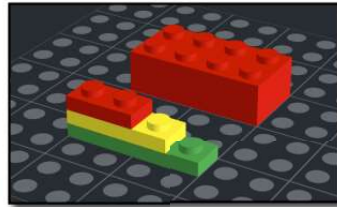
# Robot Build

## Measuring LEGO Bricks



Bricks and plates are reported in width  $\times$  length

This is a 2 $\times$ 4 brick



Bricks are 3 plates tall



Although there is a wide variety of LEGO bricks, there is a consistent method for describing them. To begin, consider the classic rectangular brick, like the one shown at the top-left of this slide.

- This LEGO piece is referred to as a “brick” because it resembles an actual building brick.
- The size of a LEGO brick is designated by the number of studs on its top.
  - ▶ A “stud” is one of the circular bumps on the top of the LEGO brick.
  - ▶ A LEGO brick’s size is reported by the width by its length in terms of the number of studs on its top.
  - ▶ For example, the red brick shown here is a 2x4 brick.

Besides bricks, there are plates, three stacked LEGO plates equals the exact same height as a single LEGO brick.

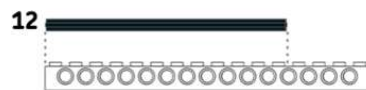
- This is a great practical application of fractions.

# Robot Build

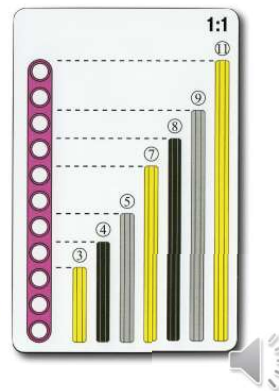
## Measuring Beams & Axels

### Body Text

The number printed next to a beam or axel is its length in LEGO modules



Axels often come in alternating colors based on their lengths



The LEGO robotics kits uses some less common pieces from the LEGO Technic product line.

- The most common Technic pieces are beams and axels.
  - A beam has rounded ends and through-holes along its connection sides, like the pink piece shown.
  - Axels are long, rod-like pieces with a plus shape when viewed from one end of the axel.
- Beams and axels are measured used a LEGO specific unit of length called a module (M).
- 1 M is equivalent to the width of one stud on a LEGO brick
- LEGO build instructions always include a number inside a circle next to a beam or axel to indicate its length.
  - To quickly measure the length of a beam, in terms of modules, count the number of holes on its side.
    - The pink beam shown here is an 11 M beam because it has 11 holes on its side.
  - To quickly measure the length of an axel, lay it on top of long brick and count the number of studs it spans.
    - The black axel shown on the top-left is 12 M axel because it spans 12 studs on the white brick.
  - Similar to beams, some 1 stud wide bricks come with holes on their sides. These are referred to as LEGO Technic bricks, and they too can be used to measure the length of an axel.
    - To further aid in quickly finding the right axel, LEGO often uses an alternating color

scheme.

- For example, in the SPIKE Prime set, the lengths of the axels go through a yellow-black-gray sequence.
- This means a short yellow axel is 3 M in length, while a medium yellow axel must have a length of 7 M.

# Robot Build

## Color Coded Pins

Friction Pins



Frictionless Pins

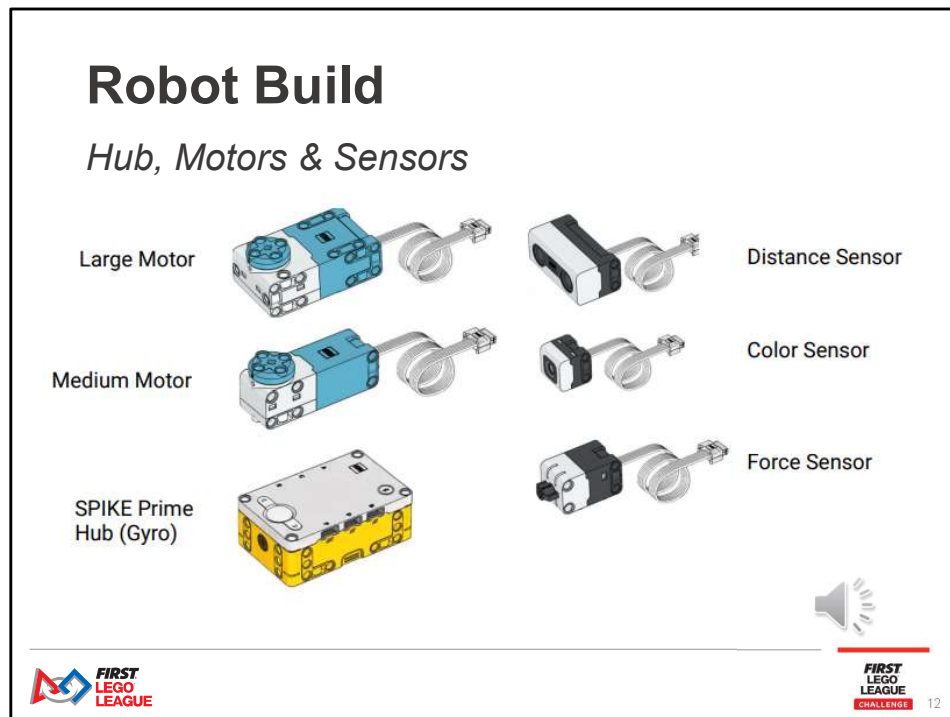


It's important to use the right pin for the right job



Pins are color coded to quickly identify if they are frictionless or not.

- Frictionless pins easily rotate when inserted into a LEGO Technic beam or brick.
- Friction pins still rotate but with some friction.
- The friction pins have slightly raised ridges along their axis and have either a black or blue color.
- The frictionless pins are smooth and come in gray and tan.
- Remember, “Blue and Black, the beam is true and intact. Tan and gray will plan to stray.”
- When building it’s important to use the appropriate pin for the job at hand.
- If the connection is meant to rotate, then a gray or beige pin should be used.
- If the connections shouldn’t rotate, then a blue or black pin should be used.



- The SPIKE Prime Hub is the main processing unit (sometimes called the brain).
- The SPIKE Prime kit comes with two types of motors:
  - one large motor; and
  - two medium motors.
- The difference in motors is their maximum torque and revolutions per minutes (rpms).
  - The large motor has a greater maximum torque, so it can rotate under greater loads.
  - The medium motors have greater maximum rpm, so they can spin faster.
- The SPIKE Prime set also comes with four different types of sensors.
  - The distance sensor uses ultrasonic sounds to measure distances.
  - The color sensor is able to measure light intensity and color.
  - The Force Sense measure if the sensor is pushed and with how much force.
  - The gyro sensor, which is actually located inside the Hub, measures orientation.
- All of the motors and sensors (except the built-in gyro sensor) have their connecting cables permanently attached to them.
  - This means if the connecting cable goes bad, the entire motor or sensor must be replaced.

# Robot Build

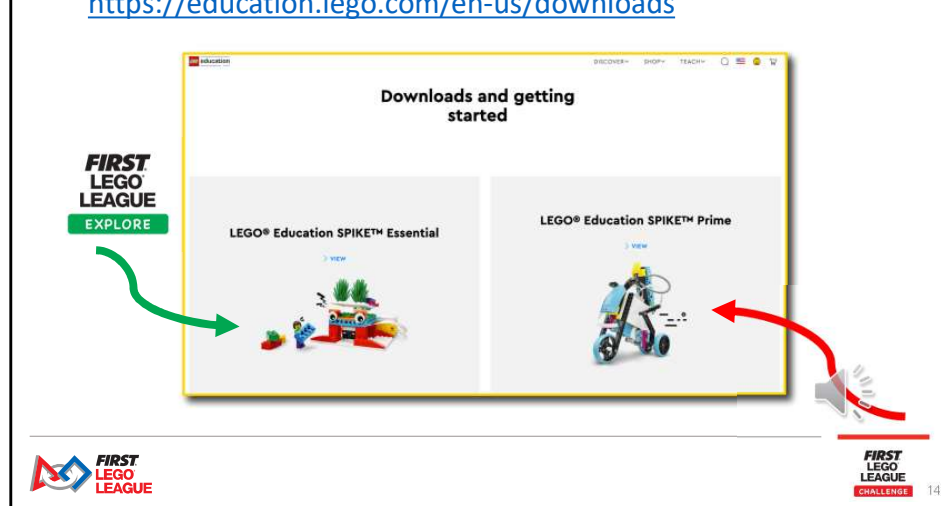
*Let's Get Started!!!*



# Robot Build

## *SPIKE App*

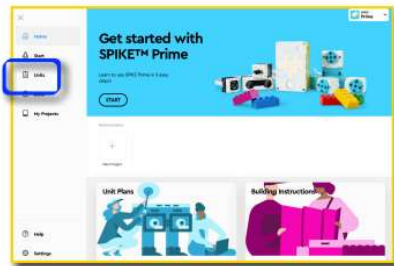
<https://education.lego.com/en-us/downloads>



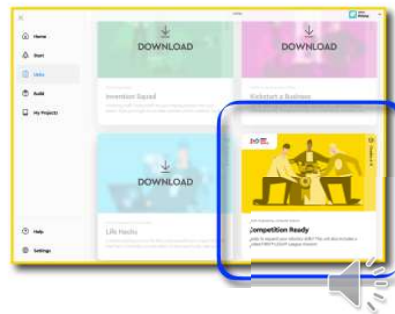
- All programming for the SPIKE Prime platform is done through the SPIKE App.
  - The SPIKE App was developed by LEGO Education and is free to download
  - There is a web-based version of the SPIKE App that does a decent job, but all FIRST LEGO League Challenge teams should download the actual app.
  - The SPIKE App allows for programming using a Scratch style program, called Word Blocks, as well as Python.
  - For those also using the SPIKE Essential platform (with FIRST LEGO League Explore), the SPIKE Essential and SPIKE Prime use the same app, which means either can be downloaded

# Robot Build

## Competition Ready Unit



The *Competition Ready* unit must be downloaded before accessing the *FIRST LEGO League* materials



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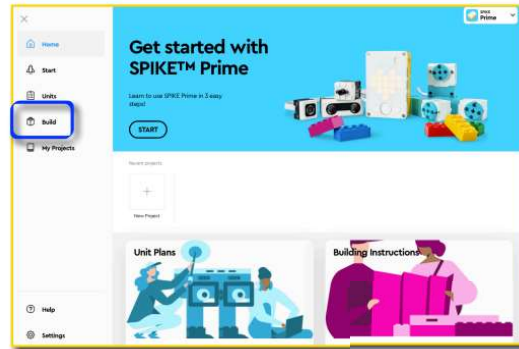
- The SPIKE App has a section called Units which contain building instructions along with tutorials.
- The Competition Ready unit is designed for the FIRST LEGO League Challenge.
  - It's important to update the SPIKE App each season to receive updated information for the current FIRST LEGO League challenge.
- Before using the FIRST LEGO League materials, including build instructions for the Advanced Driving Base, the Competition Ready unit must be downloaded.



# Robot Build

## *SPIKE App Build Instructions*

Along the left side of the HOME screen is a BUILD tab that contains instructions for building



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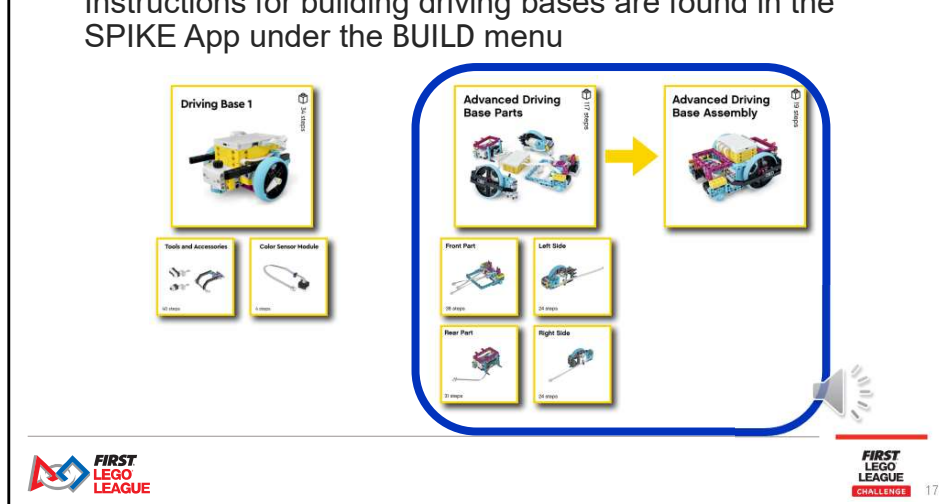
Along the left side of the Home screen is a Build tab that contains instructions for building items

- Some of the listed items can be built with just the SPIKE Prime base kit.
- Other items require the expansion set to complete, because this difference is not indicated anywhere, it's best to have the expansion kit on hand.
- Under the Build tab is the instructions for building the robot used in this workshop

# Robot Build

## *Spike App Build Instructions*

Instructions for building driving bases are found in the SPIKE App under the BUILD menu



For the SPIKE Prime platform there are two sets of robot building instructions, both of which are found in the SPIKE App under the BUILD menu.

- The Driving Base is a small, simple robot. This is an appropriate build for a small team, new to FIRST LEGO League Challenge.
  - ▶ The build only requires parts from the SPIKE Prime base set.
  - ▶ Instructions for the basic chassis-only is listed as Driving Base 2
  - ▶ The Driving Base 2 instructions includes the same basic chassis, plus Tools and Accessories.
    - This is the suggested build for a small, rookie FIRST LEGO League Challenge team.
    - ▶ Driving Base 3 is the same basic chassis plus a Color Sensor Module.
- The Advanced Driving Base is a larger robot that includes two color sensors built into it. This is the appropriate build for a larger team, new or veteran.
- The build requires parts from the SPIKE Prime base set and the expansion kit.
- Start with the instructions found in the Advanced Driving Base Parts.
- These parts can be built simultaneously, in modular form. It's a good idea to delegate out the building of these parts.
- The Advanced Driving Base Assembly instructions takes the individual robot parts and explains how to bring them together.
- Now it's time to pause this presentation and follow the build instructions for the Advanced Driving Base Parts and Advanced driving base assembly.

# Robot Build

## *Driving Base Tools*

The instructions are found under the Tools box in the Build menu.

For this workshop, build the Dozer Blade and the Lift Arm.

Do not add these tools to the Advanced Driving Base chassis until instructed to do so in a later session.



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Welcome back! Now that you have your driving base built, it's time to build your tools! The Advanced Driving Base has attachment tools that will be used to interact with FIRST LEGO League Challenge missions. The instructions are found under the Tools box in the Build menu.

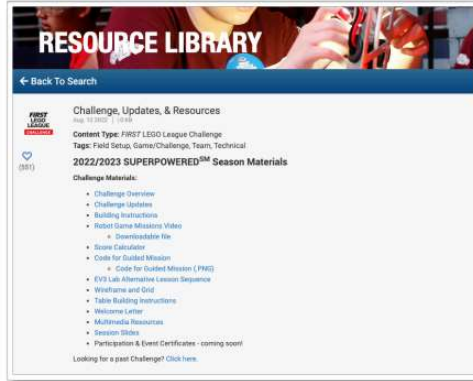
For this workshop, build the Dozer Blade and the Lift Arm.

Do not add these tools to the Advanced Driving Base chassis until instructed to do so in a later session.

Please pause this presentation while you assemble your tools.

# Resources

## Challenge, Updates & Resources Webpage



This page contains key information specific to the current season, including important rule updates & clarifications.

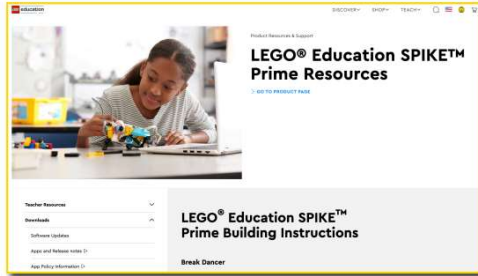
<https://www.firstinspires.org/resource-library/fll/challenge/challenge-and-resources>



There are many valuable resources available online. The Challenge, updates and resources page on the FIRST Inspires website contains key information specific to the current season, including important rule updates and clarifications.

# Resources

## PDF Instructions

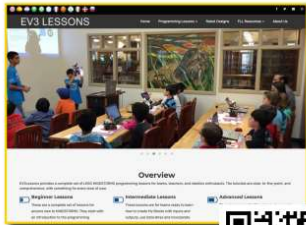


The LEGO Education SPIKE Prime Resources page has a library of build instructions for the SPIKE Prime platform.  
<https://education.lego.com/en-us/product-resources/spike-prime/downloads/building-instructions>



# Resources

## *EV3 & Prime Lessons*



EV3 Lessons website <https://ev3lessons.com/en/>

Prime Lessons website <https://primelessons.org/en/>



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Former FIRST LEGO League World Champions, “These Aren’t The Droids You’re Looking For”, have gathered years of experience into brief tutorials for new and advanced teams, and made them available on their website.

# Resources

## *FLL Tutorials*



- Team Management
- Judging Preparation
- Challenge Specific Resources
- <https://flltutorials.com/en/>



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Also from “These Aren’t The Droids You’re Looking For” is the FLL Tutorials website. - <https://flltutorials.com/en/>

- This site focuses on team management, preparing for FIRST LEGO League Challenge tournaments, and helping teams develop solutions to the Robot Game missions.
- Under the Coach’s Corner tab you’ll find a wealth of information about coaching a FIRST LEGO League Challenge team.

## Information Overload?

<https://playbook.firstindianarobotics.org/>



You may be overwhelmed by the amount of information coming at you.

All of this information will be posted in the FIN playbook and easily accessible.



You may feel like you're drinking from a firehose today. That's okay, you're still getting something to drink, and this information will be easily accessible on the FIN Playbook.





Thank you for taking the robot build self guided training. Now that you have your robot built, you are ready to move on to the Programming Self Guided training.