

# The Unofficial Guide to **FIRST LEGO League Challenge**

Updated for the 2021-22 CARGO CONNECT Season



*You are welcome to modify and use any part of this guide or any worksheets. Please credit FLLTutorials for the original work. FLLTutorials is run by Droids Robotics. Always check with your regional partner about what is required for judging in your region. Some regions may have variations in requirements as well as judging formats. [Last update: 8/20/21]*

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# WEEK 0: Before You Begin

*At the end of the 13 weeks, all team members will have learnt basic programming (moving, turning, switches, loops, basic color sensor, and a basic line follower). The goal is for your rookie team to accomplish 2-3 missions reliably during this period. All students will have also contributed to the Innovation Project and have a strong understanding of the FIRST Core Values.*

*This document provides a sample schedule for a rookie team. Feel free to modify it based on your team's background, how many times you can meet during a season, and when your first qualifier is scheduled. The recommended lessons and worksheets are resources we have created over the years for teams. You can substitute as needed if you prefer other sources.*

**Software:** You are allowed to use any software, but we will focus on the officially supported LEGO software. download and install EV3 Lab (also called EV3 G), EV3 Classroom, or SPIKE Prime software from LEGO Education's website. You are also allowed to use the MINDSTORMS Robot Inventor App. Update both the software on your computer and the firmware on your brick/hub.

**FIRST LEGO League Table:** Construct a [FIRST LEGO League Challenge table](#) according to specifications. We strongly recommend that you create an official table as this will help your students have the best experience at a competition. Tables that are as close as possible to competition tables will serve you best.

**Engineering Notebook (EN):** Every team will receive an Engineering Notebook. We will refer to pages in this document throughout this guide. In North America, check your Dashboard for a Thinkscape link.

**Robot Game Rulebook (RGR):** Every team will receive a book with the rules. It will also have information about how to set up the field. We will refer to this document in this guide. You can use this handy [electronic scoresheet](#) to track your team's progress.

**Judging:** Download the [Judging Session Flowchart](#) and the [Rubrics](#). You can also use this handy [electronic rubric](#) for self-scoring.

## Useful Contacts

- ❑ [Robot Game questions](#), [Project questions](#), [Judging questions](#), [General Questions](#)
- ❑ LEGO Education for order status or missing parts: 1-800-422-5346 or [education.lego.com/en-us/support](http://education.lego.com/en-us/support)
- ❑ Facebook Group for getting support from other coaches - [FLL Challenge: Share & Learn](#)
- ❑ EV3 Programming Lessons from Beginner through Advanced: [EV3Lessons.com](http://EV3Lessons.com)
- ❑ SPIKE Prime/Robot Inventor Lessons from Beginner through Advanced: [PrimeLessons.org](http://PrimeLessons.org)
- ❑ FIRST LEGO League Tutorials: [FLLTutorials.com](http://FLLTutorials.com)
- ❑ Challenge [Documents/Updates](#) or [Team Management Resources](#)
- ❑ Questions or suggestions for the author: [team@flltutorials.com](mailto:team@flltutorials.com)

# WEEK 1: Getting Started

## Robot Game:

1. Watch the season launch videos on the FIRST LEGO League YouTube channel.
2. Build mission models using only the [Build Instructions](#) provided by FIRST. Divide into groups of two or three and build all the models. Have an adult double check all the models. Budget about 2 hours for building mission models and placing them on the mat. [Watch this video for tips.](#)
3. Read the Mission Model Placement section (in the Robot Game Rulebook, pg. 5-6) to attach the models to the challenge mat. [Watch this video for help with model placement.](#) Watch this video for help with [how the mission models should operate.](#)
4. Learn the missions - What are their names? What is the objective of each mission? (Download mission cards here to place on your table: [Learn the Missions](#))
5. Check the FIRST LEGO League website for [Robot Game Updates](#). Sometimes, there are updates even on the first day.



## Innovation Project:

1. Read the Engineering Notebook (pg. 7) to learn what the topic is this year and what the requirements are for the season. Identify some key words or requirements for this year's Innovation Project.
2. Check for Innovation Project [Updates](#) on the FIRST LEGO League website.

## Core Values:

1. Develop a team Identity: Pick a team name. Come up with a logo. Design a team shirt.
2. Decide on Team Goals. Use the Rubrics available on the FIRST LEGO League website as your guide. ([Core Values Worksheet](#): Team Goals)
3. Learn the FIRST Core Values ([Core Values Worksheet](#): Learn Core Values)
4. Consider setting up a [Kanban board](#) for the team. A team checklist may also be helpful. ([Core Values Worksheet](#) Team Checklist)



## Homework:

1. Brainstorming: What sort of problems do you see in your community related to the challenge? Bring your ideas to the next session.
2. Download and read all the rules in the Robot Game Rulebook and Watch [Getting Start Guide](#).

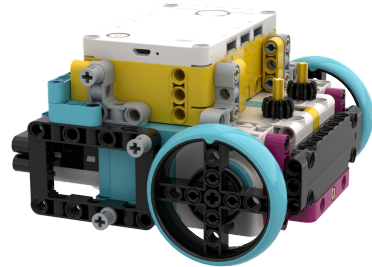
**Useful References for the Coach:** [Coaching Core Values](#), [Coaching Robot Game](#), [Coaching Innovation Project](#), [FIRST LEGO League Deliverables](#).

# WEEK 2: Learning to Program

Check for [Updates](#).

## Robot Game:

1. If you are a rookie team, we recommend [COR3](#) for EV3 (available on EV3Lessons.com) or [DroidBot M](#) (primelessons.org)
2. Learn to move forward and turn
3. If you have some programming experience, you can skip ahead to learn more advanced coding (see EV3Lessons.com or PrimeLessons.org) or start to build your team robot.



Recommended Programming Lessons on [EV3Lessons.com](#): Introduction to Brick and Software, Port View, Moving Straight, Turning

Recommended Programming Lessons on [PrimeLessons.org](#): Units 2-3

## Innovation Project:

1. Look at the mission models for inspiration. What problems do you think the models represent? Use the Project Sparks from the Engineering Notebook.
2. Discuss the homework assignment. What problems did your team find interesting in your community? How will these make a good project topic for your team?
3. Watch [Getting Started - Innovation Project](#) section and watch [How to Pick a Project Topic](#) video from the playlists.

**Core Values:** Do a teamwork activity to get to know each other. Decide how you will make decisions this season (Voting? Team leader?).

Sample activities can be found here: [Core Value Activities](#)

Recommended Lessons: [Introduction to Core Values](#), [Making Decisions](#)

## Homework:

1. Take your brainstorming ideas and develop them into Innovation Project topics. You should do enough research on your topic so that you can explain it in detail to your team members the following session. ([Innovation Project Worksheets](#): Project Identification, Research, Research Notes)

# WEEK 3: Developing a Team Strategy

Check for [Updates](#).

## Robot Game:

1. Discuss the rules and Challenge Updates that may change the rules.
2. Watch [Robot Game Strategy](#) (#3). Come up with a team strategy. If you are a rookie team, pick two or three missions to start with and divide them amongst your team. Missions near launch or near lines are easier to navigate to. (Complete [Robot Design Worksheet](#): Mission Evaluation and Robot Strategy)
3. Think about what mechanism could solve the mission(s) and who will work on them.
4. Learn to use the Color Sensor this week so you can make use of any lines.  
(Recommended Lesson: [EV3Lessons.com](#): Introduction to the Color Sensor and [PrimeLessons.org](#): Unit 5)

**Innovation Project:** Based on the homework, decide as a team what problem to work on and split the topic equally among the team members for homework. This time everyone is working only on one topic that the team picked.

*Team Tip: "Always pick a project that is meaningful to the team members and something that interests them."*

**Core Values:** Learn what pseudocode is and the importance of giving accurate instructions. [Pseudocode Peanut Butter Worksheet](#). (Recommended Lesson: [Pseudocode](#))

## Homework:

1. Different students should research different aspects of the chosen problem in order to divide the work among the group. Go into more detail this week using the same worksheets.
2. Collect Background information on the problem (where does this problem exist), Possible Field trips/Experts, Existing Solutions for this problem.
3. Different students can fill in different sections of the worksheets.
4. Document all your research. ([Innovation Project Worksheet](#))

# WEEK 4: What's our Problem?

Check for [Updates](#).

## Robot Game:

1. Learn to Line Follow. (Recommended Lessons: [EV3Lessons.com](#): Loop, Switches, Basic Line Follower. [PrimeLessons.org](#): Units 6 and 7)
2. Test your line follower out on the actual challenge mat
3. Document your tests. Can you make the line follower smoother/faster?

*Team Tip: "Learning to use sensors can help your team be more reliable. It is worth the effort, even if you are a rookie team. Start with sensors such as Touch and Color."*

## Innovation Project:

1. Discuss findings from homework. Decide where to go on field trips and whom to talk to and contact people.
2. Start to think of possible solutions. ([Innovation Project Worksheet](#): Solution Identification)
3. At the end of this week, team members should be able to clearly articulate the problem your team is studying. It should fit the innovation project criteria. You should have some idea of what a solution might be.

**Core Values:** Do a Core Value Activity that might require [coordination among members](#).

| Solution Identification   | Name: |
|---|-------|
| <small>Instructions:</small><br>1. Once your team has picked a problem, think about how to solve it<br>2. What solutions exist already? How will your solution be different?<br>3. Can you make a prototype? Can you test the idea?<br>4. Always refer to the official challenge text for requirements. |       |
| <small>What solutions exist for this problem?</small>   |       |
| <small>Can we solve the problem in a new or better way? Can it be made easier or cheaper?<br/>(Remember: solution must be a "piece of technology")</small>  |       |
| <small>How can we test the idea? What kind of "model or prototype" can we make to show the solution?</small>  |       |

# WEEK 5: First Mission

Check for [Updates](#).

## Robot Game:

1. Finish the last programming lesson: Move an Object (Programming Lesson: [EV3Lessons.com](http://EV3Lessons.com): Move an Object)
2. Look at the [Air Drop Share Guided Mission](#) provided by FIRST – build the robot attachment provided.
3. Review programming lessons such as moving, turning and using the color sensor as needed to complete the missions you selected using the strategy you decided upon.



*Team Tip: “Don’t be afraid to change, adapt or improve a solution you see. Sometimes, you can come up with something better.”*

## Innovation Project:

1. Develop questions for any interviews/field trips you may have scheduled. Experts like it when students are prepared. ([Innovation Project Worksheet](#): Expert Interviews)
2. It might be useful for you to develop a short presentation to be able to explain to your experts what you are working on and also include what FIRST LEGO League is and this year’s challenge is about.

**Core Values:** If you have time this season, you can share your progress/work with the community. You might also be able to reach out to another team for help. (Recommended Lesson: [Outreach in FIRST LEGO League](#))

## Homework:

1. Watch the [Robot Design](#) video (#4).



# WEEK 6: Let's Build a Robot

Check for [Updates](#).

## Robot Game:

1. Build your team's robot. Keep it simple. Focus on sturdy and reliable. If you start with a basic robot design, think about how to modify it. What does the robot need based on the mission strategy and missions you picked? (Complete [Robot Design Worksheet](#): Robot Design)
2. Once a basic team robot is ready, test it out to make sure it is balanced and accomplishes what you want it to. Refer to the Robot Design Rubric to see what criteria is used in judging. (Complete [Robot Design Worksheet](#): Robot Testing)
3. Brainstorm how you might solve the missions you picked
4. Start to build attachments to solve missions. Write pseudocode for your programs. (Complete [Robot Design Worksheet](#): Pseudocode)

Alternative Robot Designs for inspiration: [FLLTutorials Robot Designs](#). If you use any designs for inspiration, be sure to cite your sources and let your judges know.



**Innovation Project:** Go on a field trip and/or meet an expert this week.

*Team Tip: "Experts can provide very valuable advice. Think outside-the-box for experts. They don't even need to be near you. You can contact them by phone, email or Google Hangouts."*

**Core Values:** Do a Core Value Activity that teaches [coming to a consensus](#).

| Robot Testing   |  | Name:  |  |
|---|--|--|--|
| <b>Instructions:</b><br>1. If you design more than one robot, use this chart to compare them. At the top of each column, describe your robot.<br>2. Come up with some basic tests to compare the robot designs. Can this robot move straight accurately? Can it turn consistently? Can it line follow? Can it detect a line? Did the robot move as intended?<br>3. Discuss which robot performed the best to help you pick the best design for your team. |  |  |  |
|   | <b>Robot 1:</b><br>Wheels:<br>Size:<br>Sensors:<br>Motors: | <b>Robot 2:</b><br>Wheels:<br>Size:<br>Sensors:<br>Motors: | <b>Robot 3:</b><br>Wheels:<br>Size:<br>Sensors:<br>Motors: |
| Move Straight 50cm  |  |  |  |
|   |  |  |  |
|   |  |  |  |
|   |  |  |  |
|   |  |  |  |
| Overall: Speed Balance  |  |  |  |

# WEEK 7: Developing Solutions

Check for [Updates](#).

## Robot Game:

- 1) If you didn't finish building a base robot last week, keep working on this.
- 2) Keep building attachments and keep working on programming missions.
- 2) Keep recording changes and testing ideas. (Complete [Robot Design Worksheet](#): Attachment Evolution)
- 3) Save your program often and backup your code at the end of every meeting (onto a USB drive or Google Drive, email a copy to your coach/yourself, etc)

## Innovation Project:

- 1) Go on any field trips and/or conduct expert interviews.
- 2) Develop your Innovative Solution for your problem. What makes it innovative? ([Innovation Project Worksheet](#): Solution Identification)

## Core Values:

- 1) Do any team building activity. How about [building a City](#) together?

*Team Tip: "Remember to involve others in coming up with ideas. Be willing to listen to each other and help each other. Incorporate the Core Values into every practice."*

| Solution Identification   | Name: |
|---|-------|
| <b>Instructions:</b><br>1. Once your team has picked a problem, think about how to solve it<br>2. What solutions exist already? How will your solution be different?<br>3. Can you make a prototype? Can you test the idea?<br>4. Always refer to the official challenge text for requirements. |       |
| What solutions exist for this problem?  |       |
| Can we solve the problem in a new or better way? Can it be made easier or cheaper? (Remember: solution must be a "piece of technology")   |       |
| How can we test the idea? What kind of "model or prototype" can we make to show the solution?   |       |

## WEEK 8: Testing, Testing, Testing

Check for [Updates](#).

### Robot Game:

1. Keep building attachments and keep working on missions. Keep recording changes and testing ideas. (Complete [Robot Design Worksheet](#): Attachment Evolution and Attachment Testing.)
2. Remember to backup your code
3. Always comment your code so that others can understand it or if another team member needs to work on the code the following week.

[illegible]

### Innovation Project:

1. Develop a prototype or find a way to test or evaluate your solution. Refer to the rubric.
2. Compare your solution with existing solutions. ([Innovation Project Worksheet: Research](#))



### Core Values:

1. Remember that it is important to incorporate core values into your team. Talk about how you used the Core Values today.
2. If possible, share what you have done with other classes or your community. Share with another team or help another team.

## WEEK 9: Reliability is Key!

Check for [Updates](#).

## Robot Game:

1. Keep working on missions and making them more reliable. As you complete missions, run your robot 10 times and see how reliable your solutions are. If your solutions do not work well enough, think about how you can improve them. Take a look at the [eight Robot Reliability Lessons](#) for ideas.
2. Record how you tested your ideas and changes you made. (Complete [Robot Design Worksheet](#): Attachment Evolution and Attachment Testing.)
3. Track how many points you are able to score and how reliable your missions are. Use a tool like this [scorer](#). Complete [Robot Design Worksheet](#): Reliability.

*Team Tip: “It is more important that a few missions work well, rather than trying to do all the missions.”*

**Innovation Project:** Share your solution and get feedback on your ideas.

**Core Values:** Do a teamwork activity that helps you learn the value of working together. Activities can be found here: [Core Value Activities](#)

[illegible]

## WEEK 10: Keep Improving!

Check for [Updates](#).

## Robot Game:

1. Keep working on improving missions or adding a new one if the first few are working well.
2. Remember to record your thought processes, tests and always back up your code. Well-commented code can help you in judging.

**Innovation Project:** Improve your project solution based on feedback received.

*Team tip: “The biggest lesson from FIRST is to keep improving. Failure is part of the process. And there are always ways to improve.”*

|                        |        |                   |        |
|------------------------|--------|-------------------|--------|
| Attachment Testing     |        | Name:             |        |
| Date:<br>Mission Name: |        | Attachment Tested |        |
|                        |        |                   |        |
|                        | Test 1 | Test 2            | Test 3 |
| What worked well?      |        |                   |        |
| What did not work?     |        |                   |        |
| Next steps             |        |                   |        |

### Core Values:

1. Do a Core Values Activity to describe your [team identity](#).
2. Can each of your team members give examples of how the [Core Values](#) have impacted each of them? Review the Core Values if needed.

**Homework:** Brainstorming: How do you want to present your project to the judges? Game Show? Advertisement? You can watch some YouTube videos of specific project presentations for inspiration. There are several linked on the last page of [this lesson](#).

# WEEK 11: Starting to Wrap Things Up

Check for [Updates](#).

## Robot Game:

1. Keep improving missions.
2. Make sure missions you worked on before are still working reliably as you add more.

## Innovation Project:

1. Finalize your Innovative Solution.
2. Decide on a presentation style and develop your presentation for your judges. (Recommended Lesson: [Project Presentation](#))
3. Complete the [Innovation Project Worksheet](#): Presentation

**Core Values:** Do a Core Values Activity to learn the importance of [giving good instructions](#). Some regions may ask for a Core Values Poster. If one is required, start a [Core Values poster](#). Some regions will specifically ask you not to bring a poster, so check in advance. In past years, a template was provided for the poster. Check to see if guidelines are available from your Program Delivery Partner (PDP) or FIRST.

**Homework:** Start thinking about your judging presentations for all three areas. What do you want to communicate to the judges and what do you want to show them?

1. Complete the [Innovation Project Worksheet](#): Elevator Pitch.
2. Complete the [Robot Design Worksheet](#): Judging Preparation.

|   |       |
|---|-------|
| Presentation                              | Name: |
| What type of presentation should we give? |       |
|   |       |
| Write the script:                         |       |
|   |       |

|  |       |
|--|-------|
| Solution Summary   | Name: |
| Elevator Pitch (The Problem, How the Solution Solves It) |       |
|  |       |
| Drawing or Image of Prototype                            |       |
|  |       |

# WEEK 12: Finalizing

Check for [Updates](#).

Take a close look at the [Judging Session Flowchart](#). Notice that your team will have the opportunity to present and answer questions. Ask your regional partner if you will be allowed to make a practiced presentation for the Introduction and Core Values portion of the session.

## Robot Game:

1. Finalize your robot game
2. Start to practice robot runs. Who will run the robot? How will you switch in and out?
3. What features do you want to highlight in robot design judging? Recommended Lesson: [Robot Design Judging](#)

## Innovation Project:

1. Finalize the presentation script and any other materials (poster, props, handouts, etc).
2. Make sure that all students have a role and practice the presentation.



**Core Values:** Finalize any presentation/poster board. Do a Core Values activity that lets everyone know you appreciate their contribution. [Compliments](#) or [We are a Team](#) are great choices.

Image Credit: Girls of Steel FRC Team. Activity by Droids Robotics.

**Homework:** Practice your presentation lines.

**Useful References for Coaches:** [Tips from Robot Design Judges](#), [Tips from Project Judges](#), [Tips from Core Values Judges](#), [Competition Day Tips](#), [Dare to Prepare](#)

*Team Tip: “Remember that your time starts when you enter a judging room. It includes any setup time. So, set up quickly so that judges can hear your story.”*

## WEEK 13: Practice, Practice, Practice

Check for [Updates](#).

Make sure every student understands the flow of the judging session. Download the [Judging Session Flowchart](#). Practice transitioning from one judging topic to the next. As you practice, use the [rubrics](#) to score yourself/have parents score you and see where you can improve.

**Robot Game:** Practice Robot Runs. Practice presentations. Get all your worksheets together for an Engineering Notebook. Have your coaches/parents ask you questions about your robot design and code. Don't forget to take your M01 model that you built as a team.

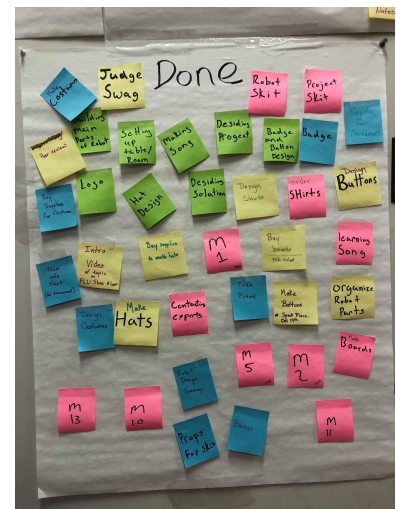
**Innovation Project:** Practice Presentations. Get all your worksheets/background research, etc together for a Research Notebook. Have your coaches/parents ask you questions about your project.

**Core Values:** Practice any presentations. Have your coaches/parents ask you questions about your season. (Recommended Lesson: [Core Values Judging](#)).

**Homework:** Pack for the tournament and practice your presentation lines.

*Team Tip: “Judges are there to celebrate your season. You should not be intimidated by them. Share what you know and what you accomplished.”*

**Useful Reference for Coaches:** [Tournament Tips](#).



*You are done. Celebrate your season!*



# APPENDIX

## USEFUL RESOURCES

### FIRST RESOURCES:

[Season Content](#)

### BOOKS:

[The Unofficial LEGO Technic Builder's Guide, 2nd Edition](#) by Pawel "Sariel" Kmiec

[LEGO Technic Non-Electric Models: Clever Contraptions](#) by Yoshihito Isogawa

[The LEGO MINDSTORMS EV3 Idea Book](#) by Yoshihito Isogawa

[The Art of Lego Mindstorms Programming](#) by Terry Griffin

[Classroom Activities for the Busy Teacher: EV3](#) by Damien Kee

[Classroom Activities for the Busy Teacher: SPIKE Prime](#) by Damien Kee

[LEGO MINDSTORMS EV3 Discovery Book](#) by Laurens Valk

[LEGO MINDSTORMS Robot Inventor Idea Book](#) by Yoshihito Isogawa

[LEGO MINDSTORMS Robot Inventor Activity Book](#) by Daniele Benedettelli

### PROGRAMMING TUTORIALS:

**EV3 Lab Programming by W.A.F.F.L.E.S Robotics**

[Beginner](#), [Intermediate](#), [Advanced](#), [Expert](#)

[EV3 Lab Programming by Carnegie Mellon University Robot Academy](#) (Possibly only accessible in USA)

[SPIKE Prime Programming by Carnegie Mellon University Robot Academy](#)

**EV3-Lab and EV3 Classroom Programming** by Droids Robotics - [EV3Lessons.com](#)

**SPIKE Prime and Robot Inventor Word Blocks and Python Programming** by Droids Robotics - [PrimeLessons.org](#)

## **FIRST LEGO LEAGUE SKILLS**

[ORTOP - Oregon FIRST](#)

FLLTutorials.com

## **FIRST LEGO LEAGUE APPS**

[Electronic Scoring and Strategy Tools](#) (also available as Apps on app stores)

## **CODE BACKUP TOOLS**

Github

Google Drive

[EV3Hub](#) (only for EV3-Lab)

Dropbox

[EV3 Online Tree Visualizer](#) (EV3-Lab)

## **ENGINEERING NOTEBOOK/NOTE TAKING**

Google Science Journal

Google Docs/Drive

Redbooth

OneNote and OneDrive

Engineering Notebooks and Coach Guidebooks by FIRST

Engineering Notebooks by FLLTutorials

Dropbox

Google Classroom

Microsoft Teams

## **TEAM COMMUNICATIONS**

Google Hangout

Skype

GroupMe

Facebook Messenger Kids

Google Classroom

Remind.com

Kakao

WhatsApp Groups

Microsoft Teams

Google Calendar

Google Group

Fleap

Whatsapp

## PROJECT MANAGEMENT

Trello  
Slack  
Basecamp

## VIDEO-MAKING TOOLS

iMovie  
TouchCast (App)  
Animot  
Camtasia  
OBS

## VIRTUAL ROBOT

[EV3 \(CMU\)](#)  
[SPIKE Prime](#)  
[Virtual Robotics Toolkit](#)  
[GEARS](#)

## BUYING EXTRA LEGO/SPARE PARTS

[LEGOEducation.com](#)  
[LEGO.com](#)  
[Brickowl.com](#)  
[Brickset.com](#)  
[Bricklink.com](#)

## LEGO CAD TOOLS:

[LEGO LDD](#) (Note: Out-of-date, no new parts):  
[Studio](#) (can import in SPIKE Prime/Robot Inventor):

## PARTS LIST/INVENTORY:

**Brickset.com** - Enter any set number (see below)  
MINDSTORMS Robot Inventor - 51515  
MINDSTORMS EV3 Retail Set - 31313  
MINDSTORMS EV3 Education Set - 51515  
SPIKE PRIME - 45678  
SPIKE PRIME Expansion V.2.0 - 45681  
[SPIKE Prime Element Overview](#)  
[SPIKE Prime Expansion V.1 Element Overview](#)