

# LEGO Mindstorms EV3 Learning Guide



Training:	Required
Reservation:	Required
Unsupervised Use:	10+
Supervised Use:	Under 10

## Certification for Machine Use

- Certification is recommended before reserving the equipment.
- Training classes last approximately 60 minutes.
- An overview of the certification process is available in this binder.
- Sign up for certification at the front desk!

## Reservation for Machine Use

- After completing certification, you may sign up for a time slot to use this set.
- To reserve, go to the front desk and ask for the Reservation Binder.
- If you are more than 5 minutes late to your reservation time, you will lose your reservation and the machine may be used on a first come-first served basis. If you are running late, please call ahead.

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# LEGO Mindstorms EV3

## Learning Guide



### Introduction to Mindstorms:

The LEGO Mindstorms EV3 robot is powered by a small computer called a LEGO EV3 Intelligent Brick. Commonly called “the Brick”. The Brick runs on the Linux operating system, so advanced users can have more fun modifying their system. The body of the robot is constructed using plastic pieces that easily snap together. The robot can be told to move forward, backward or turn. There are additional sensors that will allow the robot to sense color or react based on pressure against a touch sensor.

An infrared remote control can be used to control the robot. Lego also provides programming tools by connecting the Brick to the EV3 Programmer Software on a PC. There is also an App for Android or iOS device. This guide will show you how to command the robot using the Programming Software.

There will also be resources available to learn independently. This will include using the Color Sensor, the remote control, and much more.

## Getting Started with the Kit:

To get you started in the wonderful world of LEGO Mindstorms, this guide will take users through the following steps:

1. Review contents of the Library Innovation Studios Kit
2. Download the EV3 Programmer App on a PC, smartphone or tablet
3. Test the connection of the Brick to the EV3 Programmer Software
4. Build your robot.
5. Re-connect the Brick to the EV3 Programmer Software.
6. Program the robot through the software.
7. Other ways to control the robot.
8. Resources to Learn More

This basic overview lays the foundation for makers to design and build their own robot creations. Perhaps makers will want to start a robotics club!

For those who are ambitious, check out the First LEGO League. The 4-H Club at UNL coordinates FIRST events in Nebraska: <https://4h.unl.edu/first-robotics>

## Review Contents of the Kit

Start by clearing a big space and pulling everything out of the grey case. No need to pull out every little piece, just the larger cases. By the end, you will have the following:

Quantity	Physical Description	What's In It
2	Large Plastic Cases Labelled "Lego Mindstorm Parts"	Lego components to build the body of the robot
1	Ziploc bag labelled "Lego Mindstorm Parts"	Motors, sensors and cables for robots
1	Manual labelled "Lego Mindstorms EV3" (#31313 in lower left corner)	Manual to build Track3r robot (looks like a tank)
1	Binder labelled "Lego Mindstorms EV3 User Guide"	Manual containing basic description of parts and some troubleshooting
1	Track printed inside a Lego box	Test track for "Missions"
1	Track with red tape on white paper	Track designed for Learn the Basics
1	Laptop	EV3 Programmer Software is pre-loaded
Website	<a href="https://www.lego.com/en-us/mindstorms/build-a-robot">https://www.lego.com/en-us/mindstorms/build-a-robot</a>	Instructions to build the robots are available online

## Download the EV3 Programmer App/ Software

The EV3 Programmer software is pre-loaded onto the laptop that comes with the Library Innovation Studios kit. It should automatically connect to the Brick when you connect via Bluetooth or USB cable. **The examples in this guide use the software on the laptop.**

### ***Difference between EV3 Programmer App and EV3 Programmer software:***

The app is for smartphones and tablets and the software is for PCs. The software for PCs has more programming options. The App will give you access to the *Action Blocks* and *Flow Blocks*, but only the software will allow you to interact with the *Sensor Blocks* and *Data Operation Blocks*.

This guide dives deeper into “Programming the Robot” later on. For now, you just want to make sure you have access to the EV3 Programmer software on your PC.

### ***Downloading the software on PC:***

If you want multiple patrons to be able to access the EV3 Programmer software simultaneously, download the EV3 Programmer software on each PC:

<https://www.lego.com/en-us/mindstorms/downloads/download-software>.

Please do not connect all patrons to the same robot simultaneously. Chaos ensues. You can use the programming software without directly connecting to a Brick. Make sure patrons are connecting to the Brick and testing their program one at a time.

### ***Using the app on a smartphone or tablet:***

Search for “Lego Mindstorms programmer” in Google Play or the App Store. The developer will be listed as “LEGO System A/S”. If the app does not appear in the search, the app may not be compatible with your device.

**Note:** “LEGO Mindstorms Commander” might appear in your search results. **It is not the same thing as “LEGO Mindstorms Programmer”, and will not provide the same functionality.**

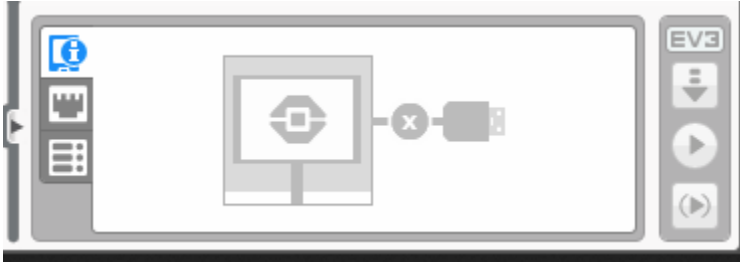
“LEGO Mindstorms Commander” is compatible with the EV3 Mindstorm Brick and is designed to command the robot similarly to the infrared remote control.

## Test Connection of Brick to PC

Before building your robot, make sure your Brick is connecting properly to your PC. It is easier to troubleshoot now without having to dismantle part of your robot to gain access to the Brick. Disconnect the USB cable again before building your robot.

### How to test:

1. Open the EV3 Programmer software on your PC.
2. Start a new project in the Software by clicking on the “+” in the upper right corner
3. The bottom right corner will have this screen to show no Brick is connected:



4. Find the USB to mini USB cable in the plastic Ziploc bag in the kit.
5. Plug the USB end into the laptop and the mini USB into the Brick.
6. Turn on the Brick (press the dark grey, center button on the control panel).
7. When the Brick connects, a **USB** icon will appear next to the battery indicator
8. In the EV3 Programmer software, the bottom right corner will look more like this (a green circle has been drawn around the icon stating USB is connected):



9. If the Brick does not connect properly, try the Troubleshooting steps below.

### Troubleshooting:

1. Try a different USB port on your computer. Retest connection.
2. Try a different USB cable (if possible). Contact Library Innovation Studios if a new cable is required.
3. Check the battery level. You may have to change batteries (6AA Alkaline).
4. Your Brick device may not be registering properly by your computer. You may need to update firmware or update your software: <https://www.lego.com/en-us/service/help/products/themes-sets/mindstorms/updating-and-resetting-lego-mindstorms-ev3-firmware-40810000007884> (or Google “Updating and Resetting Lego Mindstorms EV3 Firmware”).
5. Feel free to contact Library Innovation Studios for further troubleshooting.

# Build Your Robot

The only printed instructions available in the kit are for the Track3r robot (looks like a tank). Instructions are located in the manual labelled “Lego Mindstorms” with #31313 in the lower left corner.

Instructions for other robot types are available on the LEGO website. You can always be adventurous and build your own robot creation!

**Instructions available online:** <https://www.lego.com/en-us/mindstorms/build-a-robot>

## How to Download Instructions:

1. Click on the image of the robot you want to build
2. Click “Build [name of robot]”
3. Save and open the PDF with instructions.
4. Match the parts in the diagram with the parts in the plastic case labelled “Lego Mindstorm Parts”. Motors, sensors and cables are in the Ziploc bag.
5. Make note of which motors and sensors you use during the build. You will want to keep track of which motor is connected to which lettered port. This will be important during the programming phase.



## Connect the Brick to the Software

Since we already tested the connection of the Brick to the EV3 Programmer Software in a previous step, you should be able to plug in the USB cable to both the computer and the Brick and it should reconnect automatically.

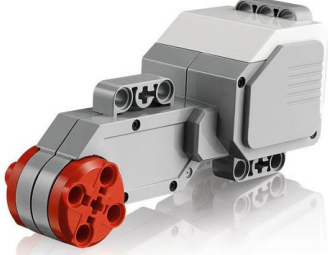





If it does not, try the Troubleshooting from the “Test Connection of Brick to PC” section.

# Programming with EV3 Programmer Software

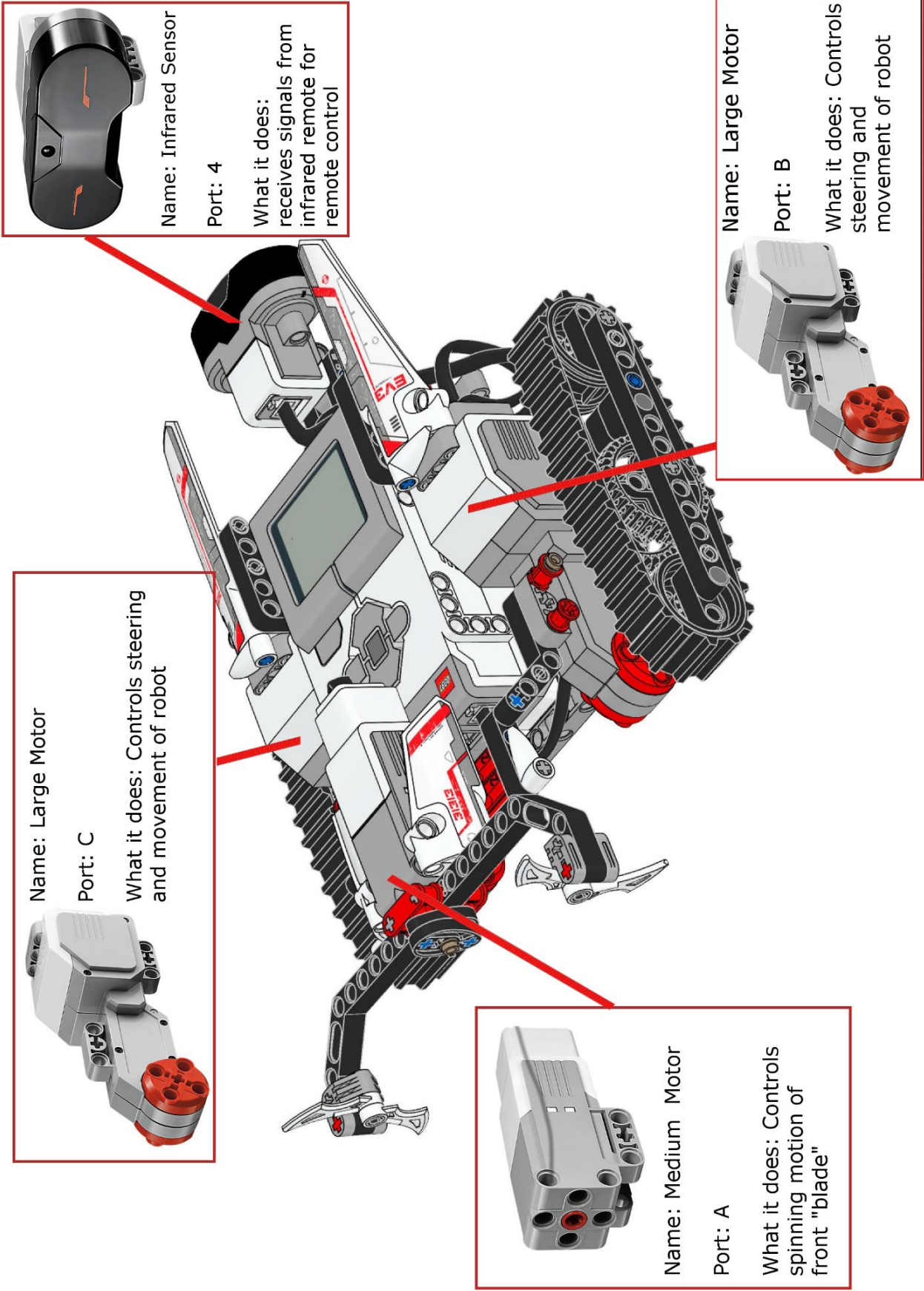
The process for learning to program has been broken down into the following steps:

1. Review the Motors and Sensors that are available in the kit
2. Look at the “Diagram of Motors and Sensors in the Track3r Robot”
  - a. Look at where the motors and sensors are connected on the robot
  - b. Review the capabilities of these motors and sensors
3. Look at the “Diagram of EV3 Programmer Software w/ Motor Icons”
  - a. Learn how the motor icons match up with the icons in the software
  - b. Look at how the Brick appears when connected to the software
4. Open the “Learn the Basics” training file.
  - a. After the Brick is connected, place the robot on start and press “Play” to see how the robot moves.
  - b. Select different steps from the program and play the selection to see how the robot reacts to different settings
5. Open a fresh project and experiment with making the robot navigate the course
  - a. Try changing the settings in different ways to see how the robot reacts
  - b. Use “Learn the Basics” as a guideline for your own experimentation
6. Review other ways to control the robot (example: Infrared Remote Control)
7. Check out the “Resources for Self-Learning” to learn more!

## Review of Motors and Sensors

Motor/ Sensor Name	What it Does
<p style="text-align: center;"><b>Large Servo Motor</b></p> 	<ul style="list-style-type: none"> <li>• Higher Torque (power), but slower speed</li> <li>• 160-170 RPM (revolutions per minute)</li> <li>• Great for moving the full robot</li> <li>• Handles major motions of heavier objects attached to the motor</li> <li>• Motors connect to lettered ports</li> </ul>
<p style="text-align: center;"><b>Medium Servo Motor</b></p> 	<ul style="list-style-type: none"> <li>• Lower Torque (power), but higher speed</li> <li>• 240-250 RPM (revolutions per minute)</li> <li>• Great for moving robot accessories</li> <li>• Handles small motions of lighter objects attached to the motor</li> <li>• Motors connect to lettered ports</li> </ul>
<p style="text-align: center;"><b>IR Remote</b></p> 	<ul style="list-style-type: none"> <li>• Works when paired with IR Seeker Sensor</li> <li>• Requires 2 AAA batteries</li> <li>• Uses infrared signal to connect to IR Seeker and control the robot</li> <li>• Must be set to the right channel according to internal settings on the Brick</li> <li>• Works up to two meters away</li> </ul>
<p style="text-align: center;"><b>IR Seeker Sensor</b></p> 	<ul style="list-style-type: none"> <li>• Works when paired with IR Remote</li> <li>• Receives infrared signal from remote to help control robot</li> <li>• Sensors connect to numbered ports.</li> </ul>
<p style="text-align: center;"><b>Touch Sensor</b></p> 	<ul style="list-style-type: none"> <li>• Detects when red button is pressed or released</li> <li>• Can be programmed to take action when button is pressed or released</li> <li>• Example: robot stops then backs up when button is pressed</li> <li>• Sensors connect to numbered ports.</li> </ul>
<p style="text-align: center;"><b>Color Sensor</b></p> 	<ul style="list-style-type: none"> <li>• Can tell the difference between blue, green, yellow, red, white, brown, and black</li> <li>• Can detect light intensity under sensor</li> <li>• Can be programmed to follow a colored line on a contrasting background</li> <li>• Sensors connect to numbered ports.</li> </ul>

# Diagram of Motors/ Sensors in Track3r Robot



# Diagram of EV3 Programmer Software w/ Motor Icons

(All added notes are in purple.)

The screenshot shows the EV3 Programmer software interface. At the top left, there is a toolbar with icons for file operations, a hand cursor, and a magnifying glass. Below the toolbar, the main workspace is empty. On the right side, there is a panel with a 'KIM' label, a battery level indicator, and a 'Firmware: V1.03E' label. Below the firmware label, there is a 'Connection Type' dropdown menu. A red circle highlights the 'Connection Type' dropdown menu. At the bottom of the interface, there is a row of motor icons, each with a different color and a play button. A purple box highlights the motor icons and the 'Connection Type' dropdown menu.

This is where you will drag and drop your motors to program functions. You can change settings in the dropped modules here.

This is where the connected Brick will appear. Click the Port View icon (circled in red below) to pull up a diagram of motors and ports.

Below are pictures of motors from the connected robot. Match the icon below to the motor diagram of Track3r. Hover over the motor icon for a description of motor function and port number. Drag and drop the desired motor next to the play button to program the robot.



# Using the “Learn the Basics” Training Track

The “Learn the Basics” mission is to follow the red line on the track provided with this kit. At the end, celebrate by spinning the “blade” and playing a celebratory sound.

The solved program will be available for reference in the “Learn the Basics” training file. Notes have been added to this program so you know which step does what.

## What you will need:

- **Track with red tape on white paper**
- **Learn the Basics training file** (*located on desktop of training laptop*)
- **Track3r Robot** (Note: *can be used with other robots but the setting for turns and forward movement may need to be adjusted to account for wheel size*)
- **Laptop that comes with the Innovation Studios Kit** (Note: *can be used with other computers with a copy of the “Learn the Basics” training file*)

## Skills learned on this track:

- Making turns (experiment with angles)
- Moving in a straight line
- Going backwards
- Turning the “blade” motor
- Adding Sounds
- Testing and adjusting the program
- Saving and Downloading to the Brick
- Accessing the Program in the Brick

## Setting up the Learn the Basics Training Mission:

1. Unfurl and tape down the track so it lays flat. Use removable tape.
2. Place the robot in the “Start” box with the “blade” facing the finish line.
3. Make sure the robot “tank tracks” are somewhat parallel to the lines in the start box. This will help with consistent degree settings during programming.
4. Open the EV3 Programming Software.
5. Turn on the Brick and make sure it connects.
6. In the EV3 Programming software, go to File- Open Project
7. Open “Learn the Basics” which is located on the desktop.
8. Look at the “With Annotations” section. This pre-programmed area will tell you how the motor reacts to different setting combinations.
9. Run the program to see how the robot will navigate.
10. Select and play different turns and movements. Watch how the robot reacts.
11. Click on the “+” across the top of the screen to start a fresh project.
12. Use the fresh project to practice on the track and play around with settings. You can use the “Learn the Basics” as a reference point as you experiment.

# Tips and Tricks for Programmers

Here are a few rules of thumb to get you started:

- Sometimes the best way to learn is by doing.
- There is more than one way to make a robot turn. Experiment with all the options in the “Move Steering” and “Move Tank” section. Try changing the degree settings or the number of rotations and watch how the robot reacts.
- Setting the motor to turn 90 degrees will not make the actual robot turn 90 degrees. Sometimes it takes more than one rotation of the actual motor to make the physical robot turn the way you want.
- Experiment with negative numbers in the degree and rotation fields. You can make the robot turn one way, then change to a negative number and make it turn the other direction.
- Pay attention to the direction the arrow is pointing in the settings field of each motor function. It can save you some time when testing your program.
- Try taping a protractor on the desk (you can print one online by Googling “printable protractor”). Put the robot on the protractor to get an idea of how your settings affect the actual degree turns of the robot.
- Do not be afraid to try new things! It is all in the name of science.

## Other Ways to Control the Robot

Here are some other ways to control the robot besides the EV3 Programmer Software.

### Infrared Remote Control

Go to Page 2 “Using the Remote IR Beacon as a Remote” in NoStarch’s article:  
[https://nostarch.com/download/samples/EV3Laboratory\\_ch6.pdf](https://nostarch.com/download/samples/EV3Laboratory_ch6.pdf)

### On Brick Programming

This method is a bit more difficult than using the Programming App or remote control. For an introductory look at programming your robot using on the Brick, check this out:  
<https://www.youtube.com/watch?v=6e2Z87KAzMw&t=124s>

## Resources to Learn Programming

**About the Motors and Sensors:** sift through the User Guide available with the kit for more information about the different motors and sensors available with the kit.

Here are some tutorials/ resources you might find interesting:

Use the Color Sensor to Follow a Line:

<https://www.youtube.com/watch?v=ye3MhVA9Rhs>

Using the Touch Sensor: <https://www.youtube.com/watch?v=DsxolAB-sYk>

Lego Website: <https://www.lego.com/en-us/mindstorms/learn-to-program>

Getting Started Programming: <https://www.youtube.com/watch?v=vv5X3zzkBk4>



# For Trainers- How to Setup a Training Station

## Space Needed:

3 x 4 ft. to allow for half-foot clearance on all sides of “Learn the Basics” track

Small desk for training laptop

*Optional:* set up a computer station for each trainee- can be done in computer room

## Setup Steps:

1. Unfurl and tape down the “Learn the Basics” training track
2. Power on the Training Laptop
3. Open EV3 Programming Software (note location on computer)
4. Open “Learn the Basics.ev3” training file (located on desktop)
5. Connect “Brick” to computer using the USB to Mini-USB cord
6. Make sure the “Brick” is recognized on EV3 programming software
  - a. Look at the bottom left corner of the screen, there should be a name listed in the Connected Brick section- active ports will also be available
7. Run the “Learn the Basics” program to verify everything is working
8. Make sure the training laptop is visible to all trainees
  - a. If trainees are viewing EV3 Software on their own computer make sure EV3 Software is downloaded and functioning on every station
  - b. Connect computers to the robot one at a time for testing, even if you opt to use a Bluetooth connection