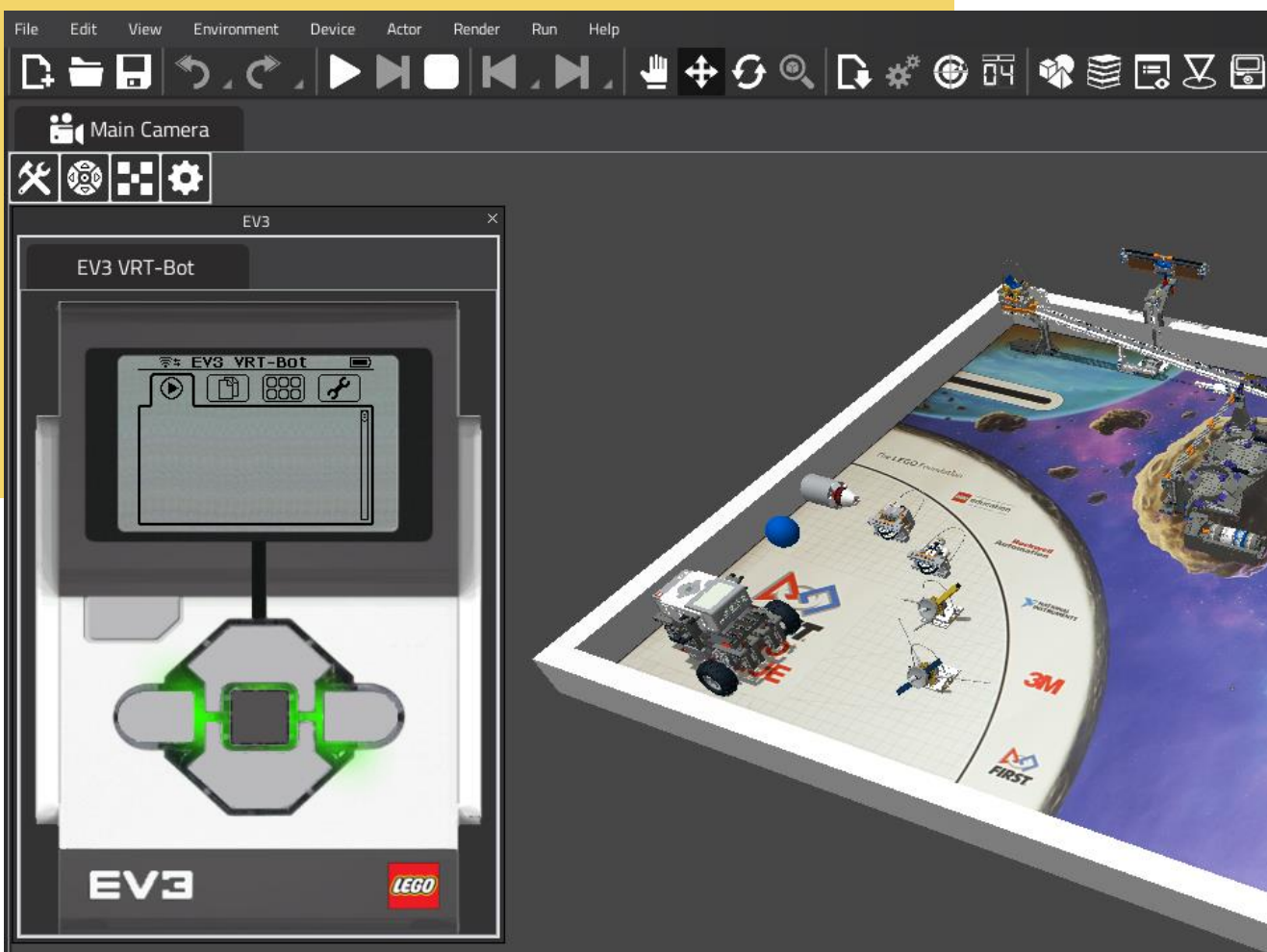


Introduction to Coding for *FIRST* LEGO League



LEGO Mindstorms & the Virtual Robotics Toolkit Tutorial



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INTRODUCTION

What is *FIRST* LEGO League?

FIRST LEGO League is a partnership between *FIRST* and the LEGO Group, designed to get elementary- and middle-school students excited about science, technology, engineering and math (STEM).

FIRST LEGO League teams design, build and program autonomous LEGO Mindstorms robots to complete tasks on a themed playing field and develop innovative solutions to real-world problems, related to the year's Challenge Theme, all in preparation for a tournament at which they demonstrate their robots and present their solutions to panels of judges.



What is the purpose of this guide?

This guide will introduce you to the basics that you will need to get started programming LEGO Mindstorms EV3 robots and introduce you the Virtual Robotics Toolkit, software that allows you design, build and program robots in a virtual environment.

How to use this guide?

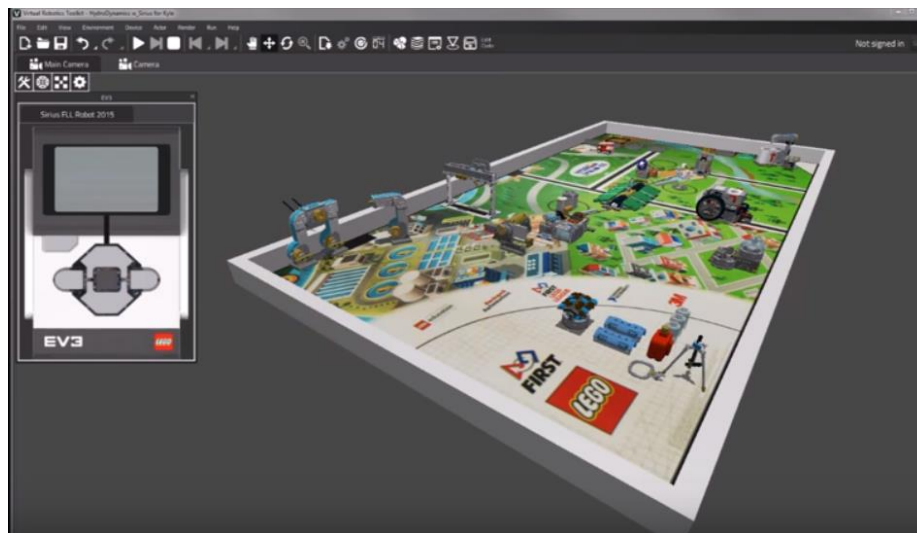
Read the background information and instructions provided and look for tasks to complete that will help you become more familiar with the capabilities and applications of the Virtual Robotics Toolkit and the LEGO Mindstorms EV3 programming software.

GETTING STARTED

In this section, we will look at how to install the Virtual Robotics Toolkit and become familiar with the user interface by exploring the various tools and features of the software.

What is the Virtual Robotics Toolkit?

The Virtual Robotics Toolkit (VRT) is a robotics simulation software that allows you to design, build and program virtual LEGO Mindstorms creations, without the need for a physical robot.



Installation and Setup

If you haven't already done so, please visit the following link to install the Virtual Robotics Toolkit for PC or Mac: <http://www.firstroboticscanada.org/cancode/vrt/>



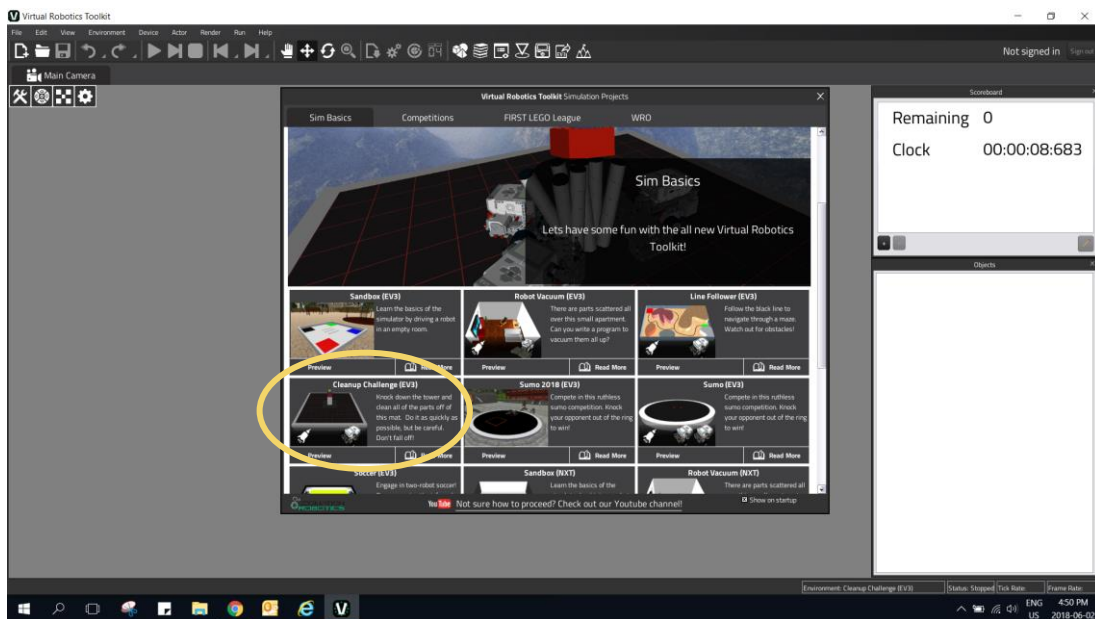
Simulator Basics

Opening a Project

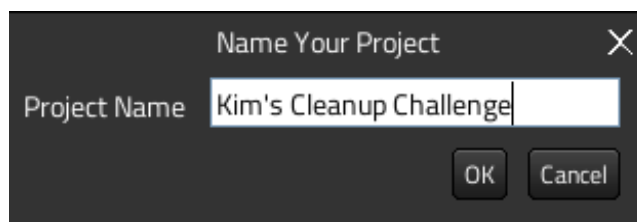
1. Launch the simulator by clicking on the following desktop icon:



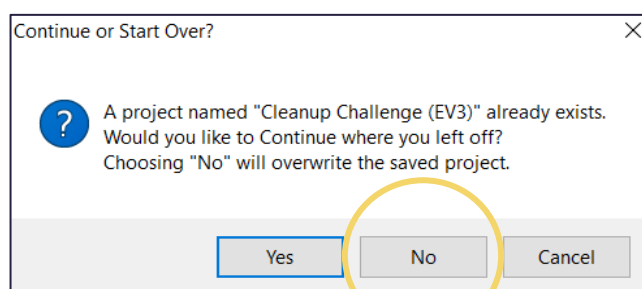
2. When you see the following welcome screen, scroll down until you see the “Cleanup Challenge” and click on it.



3. Rename your project (i.e., “Kim’s Cleanup Challenge”) and then click OK.



4. If you see the box below, click “No”, which will allow you to start with a fresh, new project.



Driving the robot using keyboard keys

- Turn on the simulator by pressing the “Play” button. A green band will appear at the top of the screen to let you know that the simulator is “on”.



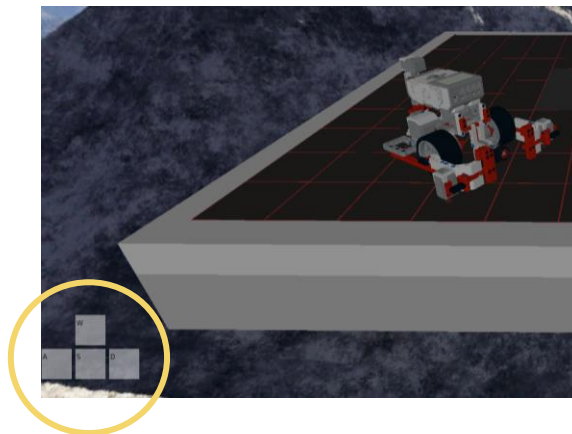
- Attempt to clear the tower by driving the robot using the W, A, S and D keyboard keys.

W = moves the robot forwards

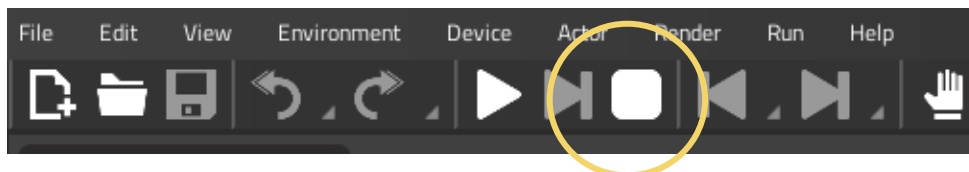
S = moves the robot backwards

A = turns the robot left

D = turns the robot right



- When finished or if your robot gets stuck on the edge of the platform, click the “Stop” button on the Toolbar to end the simulation and restore the robot back to its original position.



Moving Around with the Mouse

- Practice using the mouse to adjust your view:

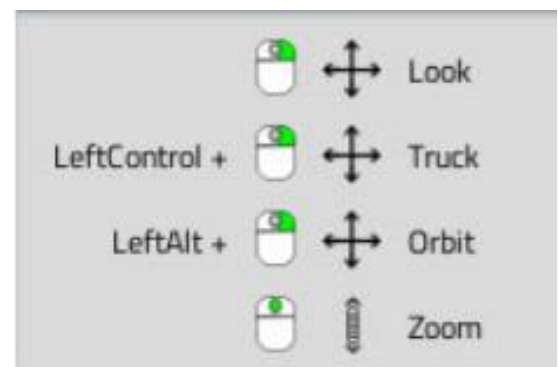
Look by right clicking on your mouse to look around

Truck by holding the left Control key + right clicking

Orbit by holding the left Alt key + right clicking

Zoom by using the middle mouse scroll wheel

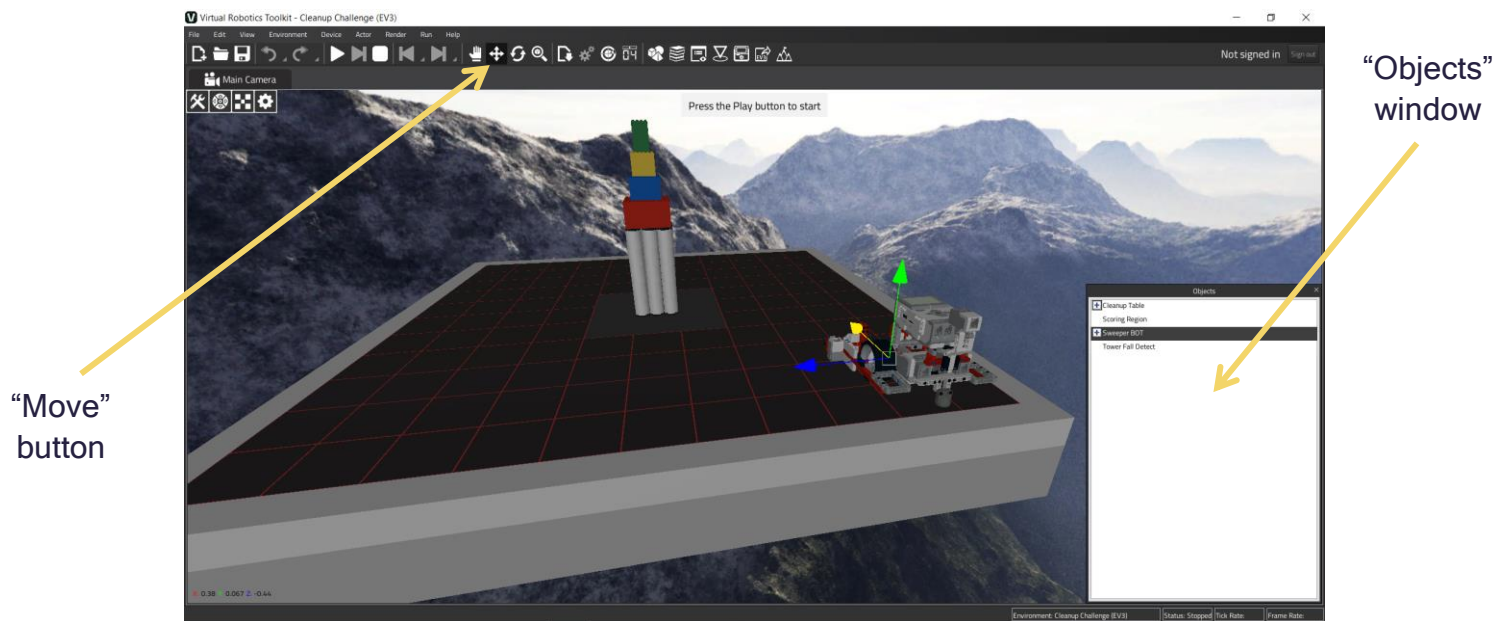
Alternatively, we can also use the keyboard to zoom in and out from an object by pressing the “+” and “-” keys.



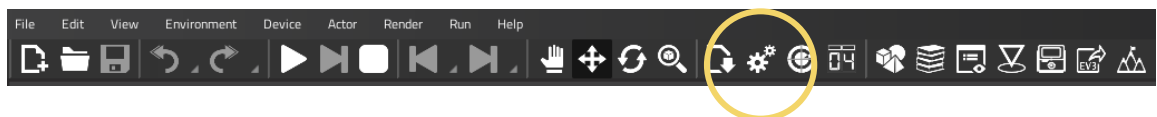
Using Attachments

Many of the sample project robots come with attachments that can be added.

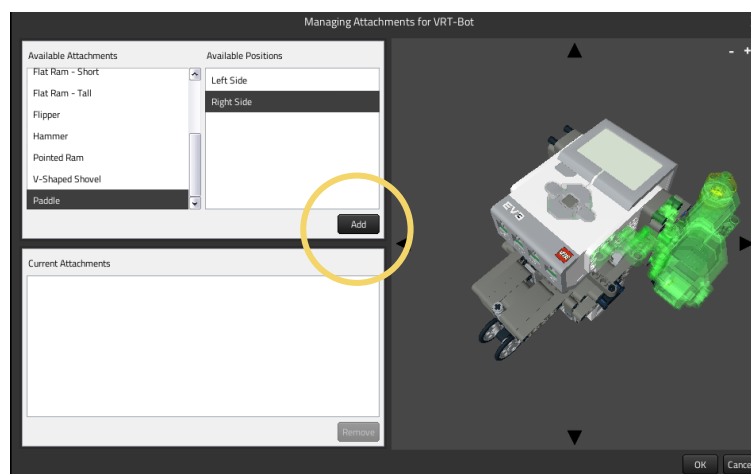
9. View the list of available attachments for the sample project robot by either clicking:
 - a) on the robot in the “Objects” window OR
 - b) the “Move” button in the toolbar and then clicking on the robot in the Main Camera



10. With the robot selected, click on the “Attachments” button, located on the Toolbar.



11. To add a new attachment, select it from the list of “Available Attachments”, choose a position on the robot and then click “Add”. Click the “OK” button to save your changes.



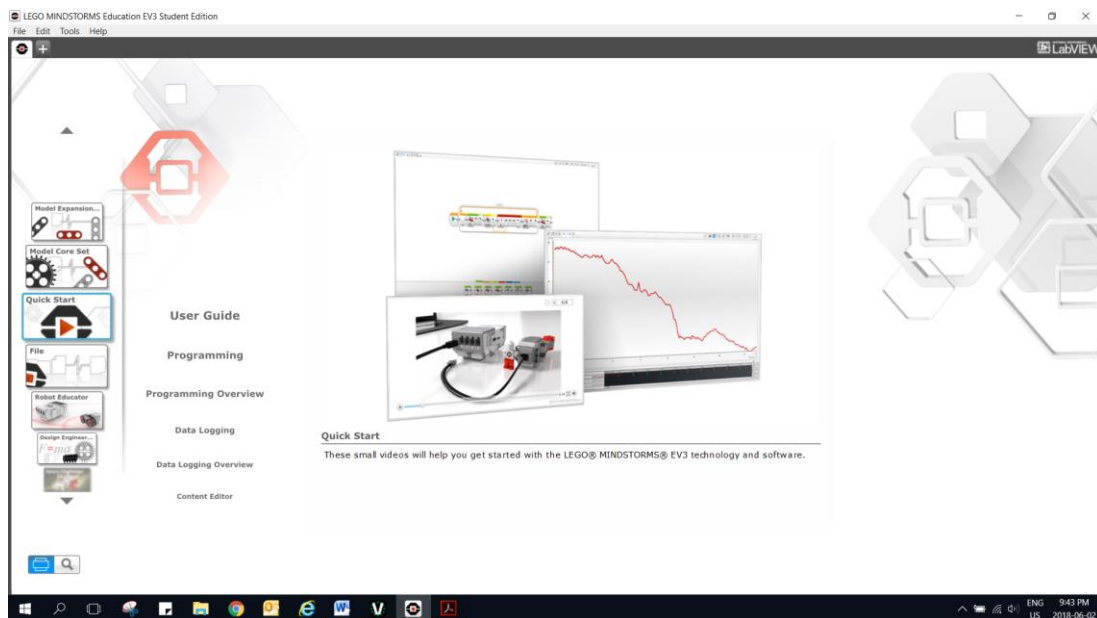
12. Repeat the Cleanup Challenge using different attachments. Which one works the best?

PROGRAMMING THE ROBOT

In this section, we will look at how to install the LEGO Mindstorms EV3 programming software, how to create a program using programming blocks and how to download the program onto the robot in the Virtual Robotics Toolkit.

What is LEGO Mindstorms EV3 Programming?

LEGO Mindstorms EV3 Programming is an intuitive, drag-and-drop software that allows users to program physical or virtual LEGO Mindstorms EV3 robots to give them abilities such as moving, following lines, avoiding objects, making mathematical calculations and much more.



Installation and Setup

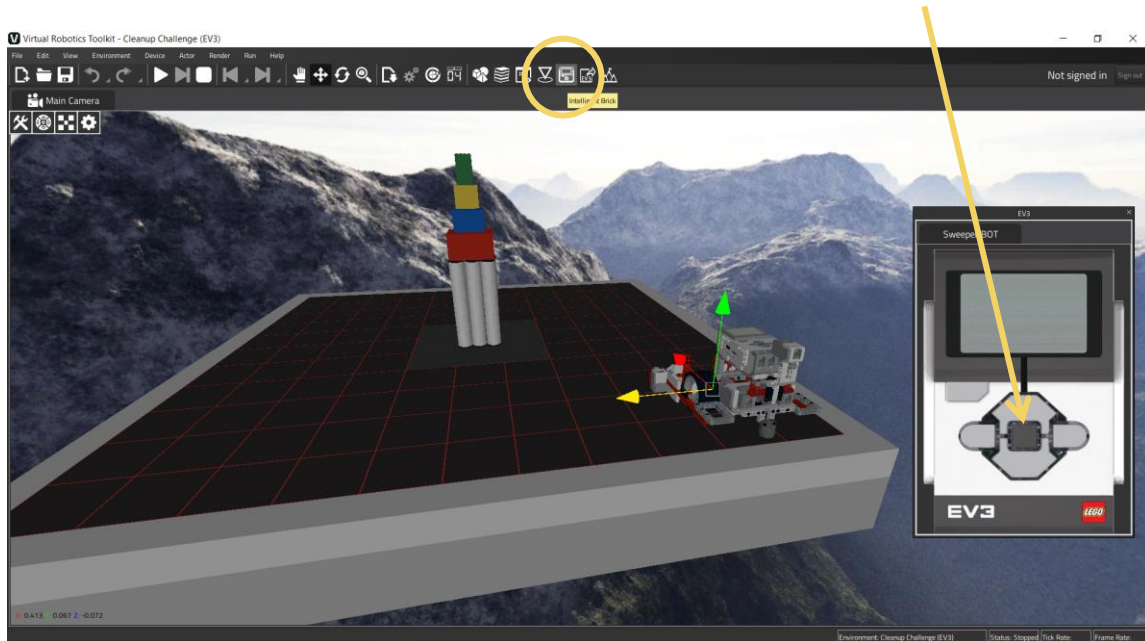
If you haven't already done so, please visit the following link to install the LEGO Mindstorms EV3 programming software for PC or Mac: <https://education.lego.com/en-us/downloads/mindstorms-ev3/software>

Creating a Program

Using the *Action* Palate

The following steps will guide you through the process of creating and downloading programs that use “Move Tank” and “Wait” blocks to make your robot autonomously clear the tower.

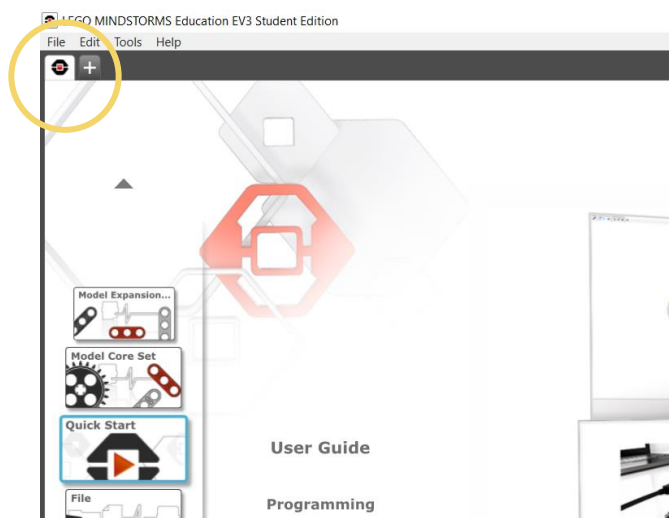
1. Open the EV3 Brick in the Virtual Robotics Toolkit by clicking on the “Intelligent Brick” shortcut in the “Objects” pane and turn on the brick by clicking the center Brick Button.



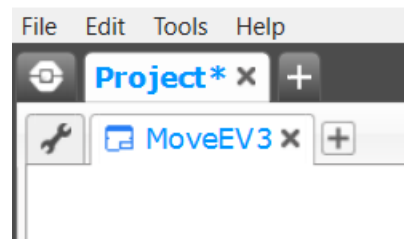
2. Launch the LEGO Mindstorms EV3 software by clicking on the following desktop icon:



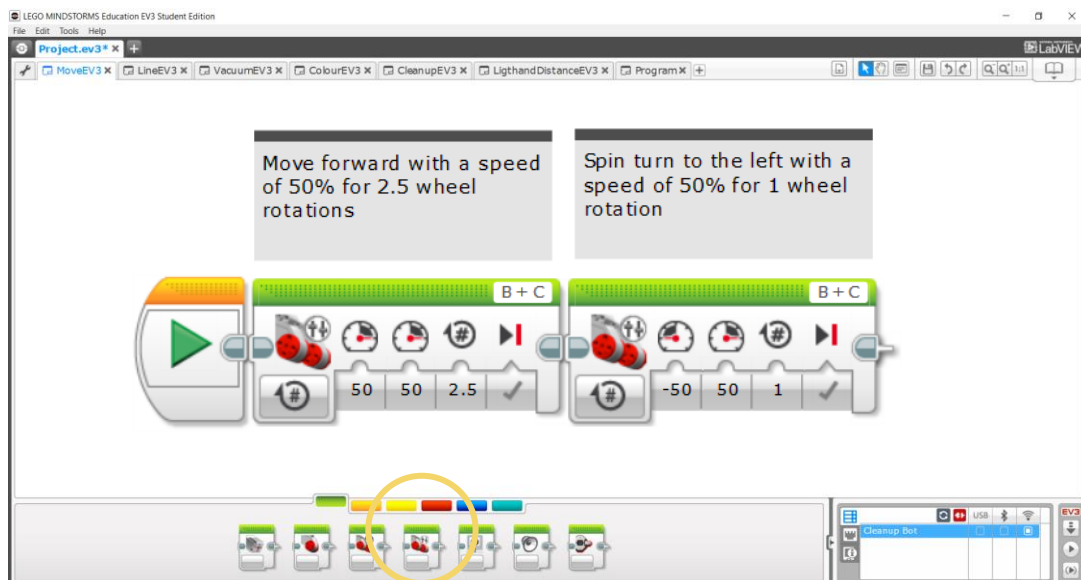
3. When you see the welcome screen, click on the “+” symbol to open a new project.



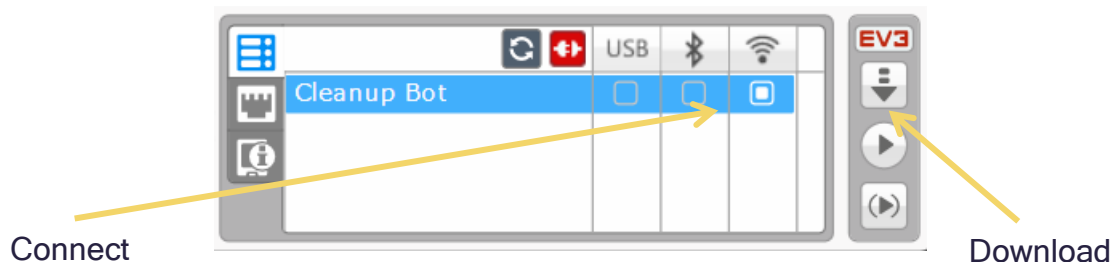
- Rename your program by double clicking on the word “Program” and replacing it with the name “MoveEV3”.



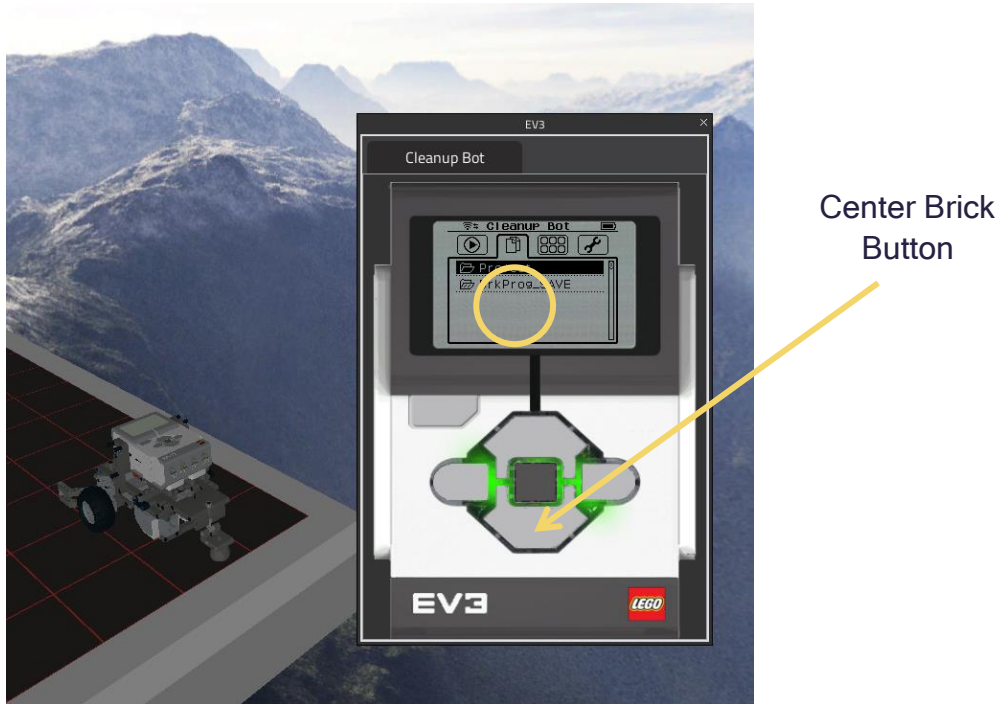
- Click, hold and drag two “Move Tank” blocks into position and change the conditions of each block as shown in the diagram below to create a program that will make the robot drive forward 2.5 wheel rotations and perform a spin turn to the left for one wheel rotation.



- Connect to the virtual brick by clicking the button underneath the Wi-Fi symbol and click on the “Download” button to download your program to the robot in the Virtual Robotics Toolkit.



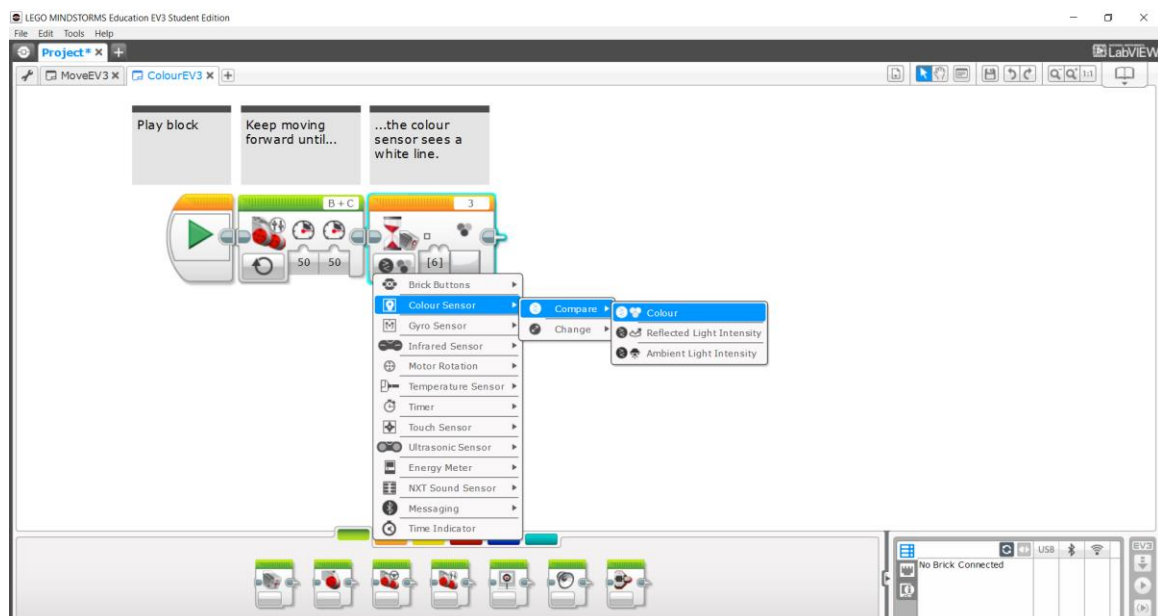
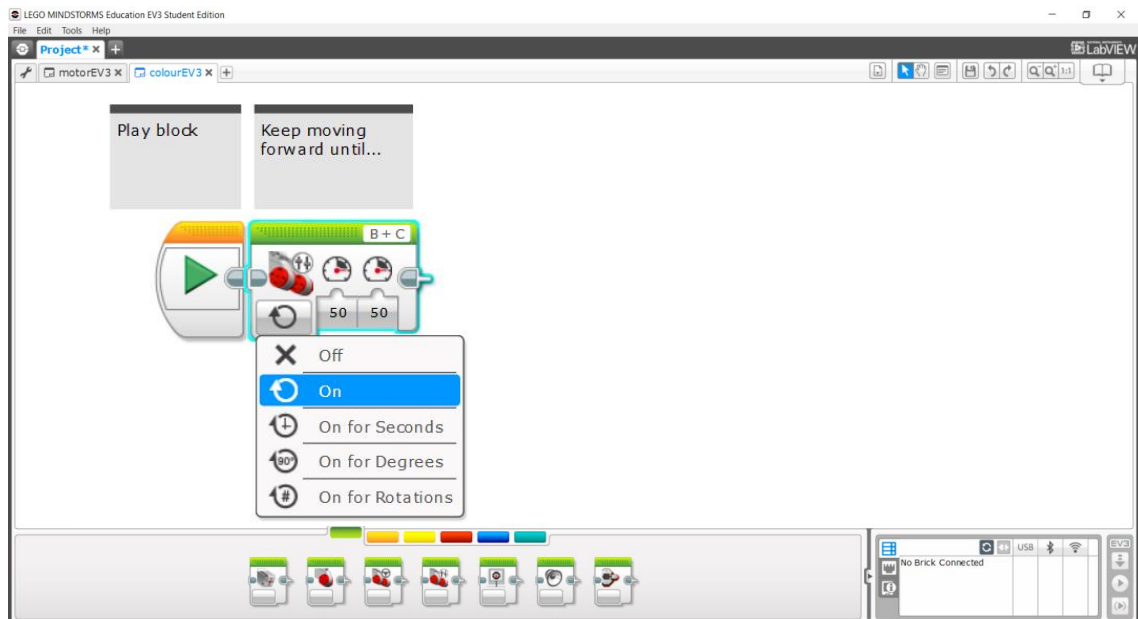
- Return to the Virtual Robotics Toolkit and use the brick buttons to access the “File Navigation” screen. Find your program in the folder titled “Project” and click the center Brick Button to run the program.

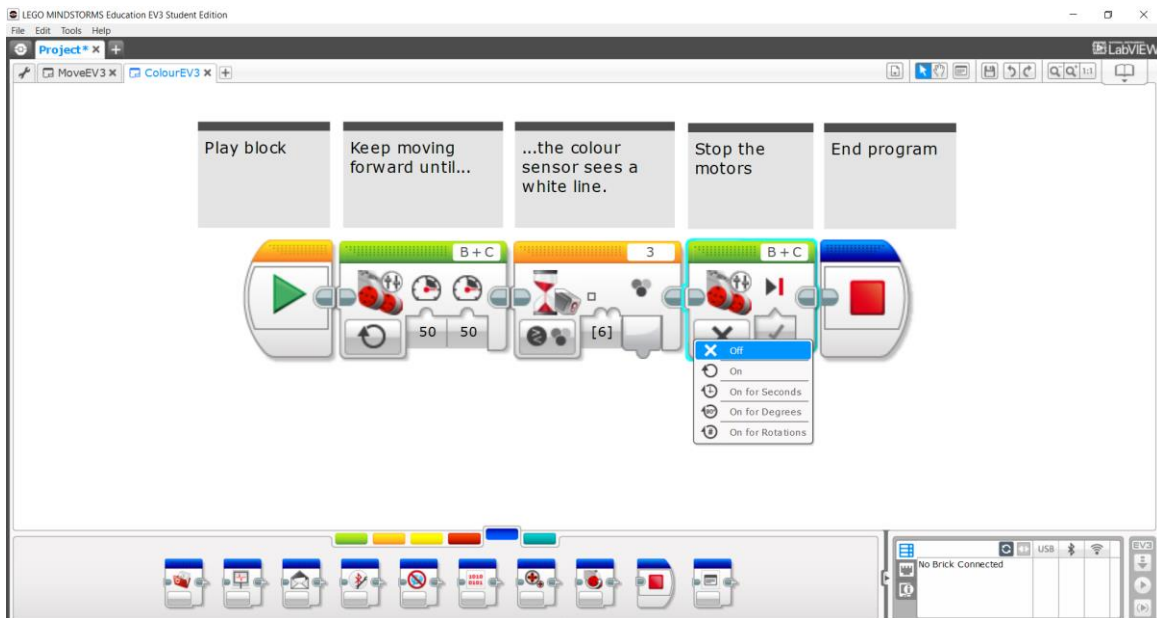
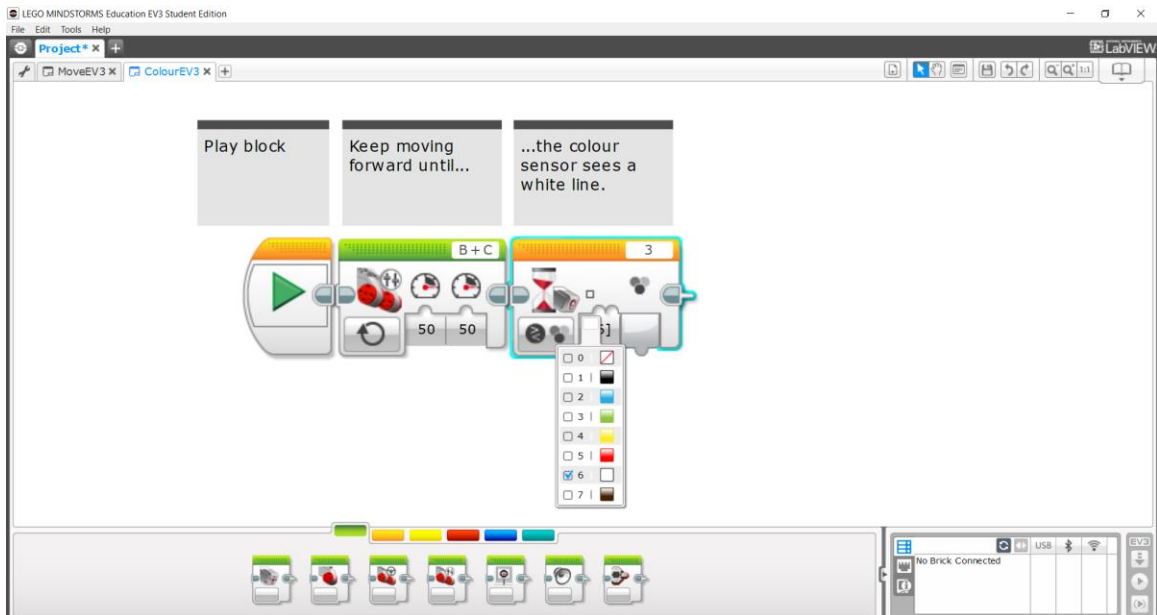


- Return to your program and add additional “move tank” blocks to make the robot drive towards and knock over the tower.

Using the *Action* and *Flow Control* Palates

9. Create a new program called “ColourEV3” and use the screenshots below to build a program that will make your robot drive forward until the light sensor detects the white border of the platform and stop before it falls over the edge.





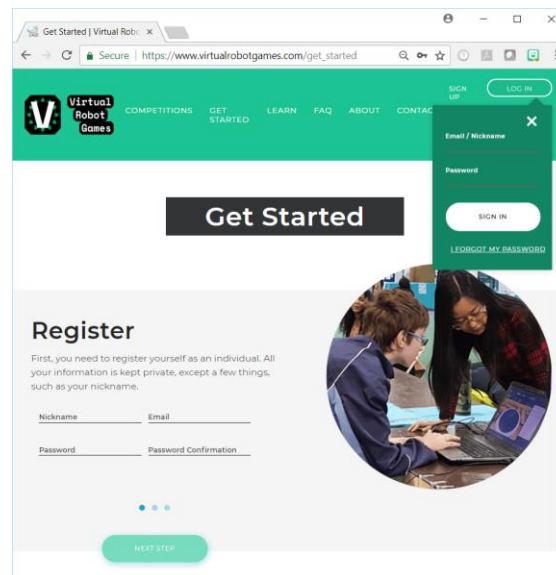
10. Download the program and run it in the Virtual Robotics Toolkit. How can the robot's ability to sense the border of the platform be used to help clear the tower? Continue with "Take the Cleanup Challenge" to find out!

TAKE THE CLEANUP CHALLENGE

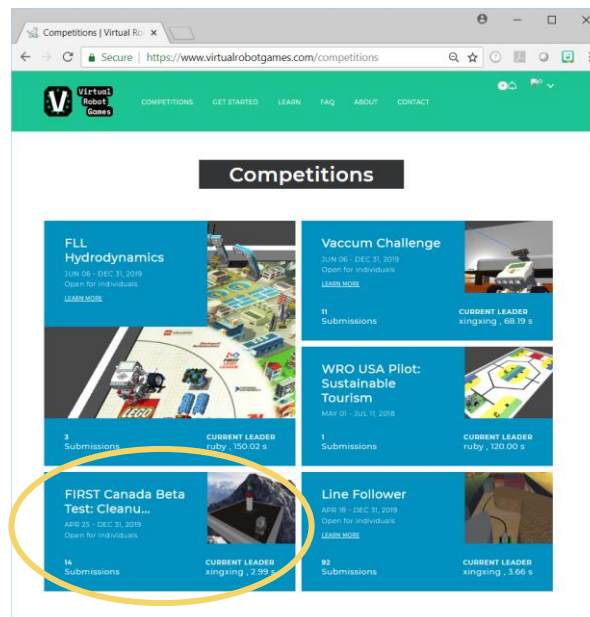
In this section, we will look at how to code the robot to complete the Cleanup Challenge autonomously and how to submit your score to the online leaderboard.

Register for the Competition

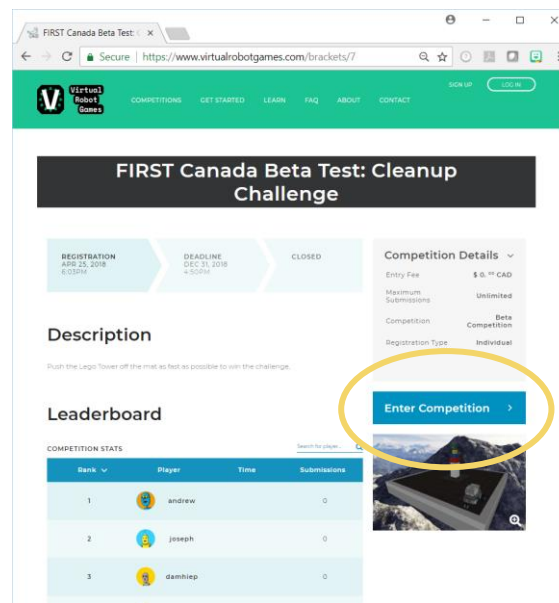
1. Visit www.virtualrobotgames.com/get_started and click on either “Sign Up” if you are a new user or “Log In” if you already have a username and password.



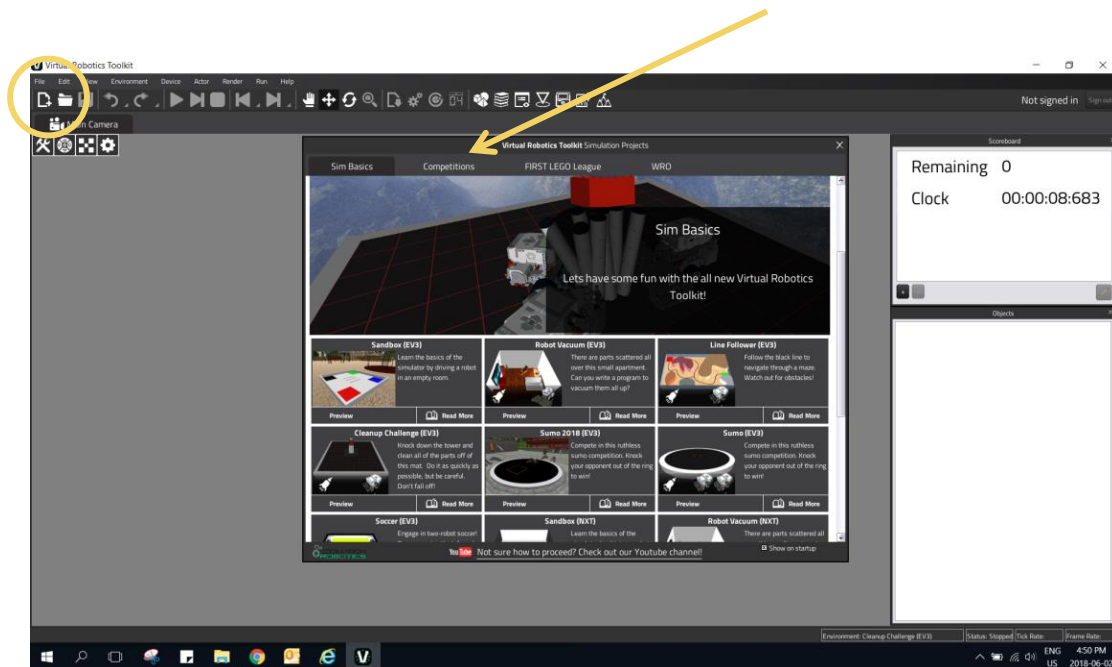
2. Once you have logged in, click on “Competitions” and select “*FIRST* Canada Beta Test: Cleanup Challenge”.



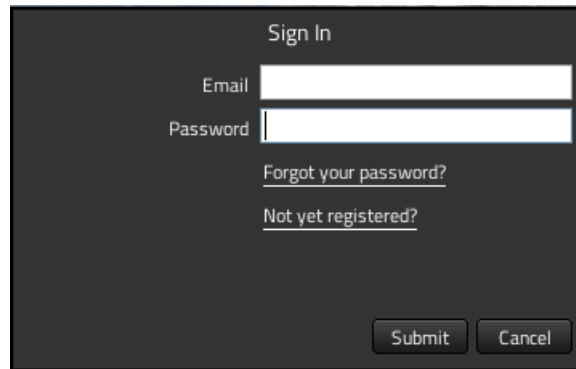
- Click on “Enter Competition” to register for the Cleanup Challenge and to add your nickname to the leaderboard.



- Open or return to the Virtual Robotics Toolkit software, click on “New” if you don’t already see the welcome screen below and click on the “Competitions” tab.



5. Enter the same email address and password as you used to sign up for Virtual Robot Games and click on “Submit”.



A dark-themed dialog box titled "Sign In". It contains two input fields: "Email" and "Password". Below the "Password" field are two links: "Forgot your password?" and "Not yet registered?". At the bottom right are two buttons: "Submit" and "Cancel".

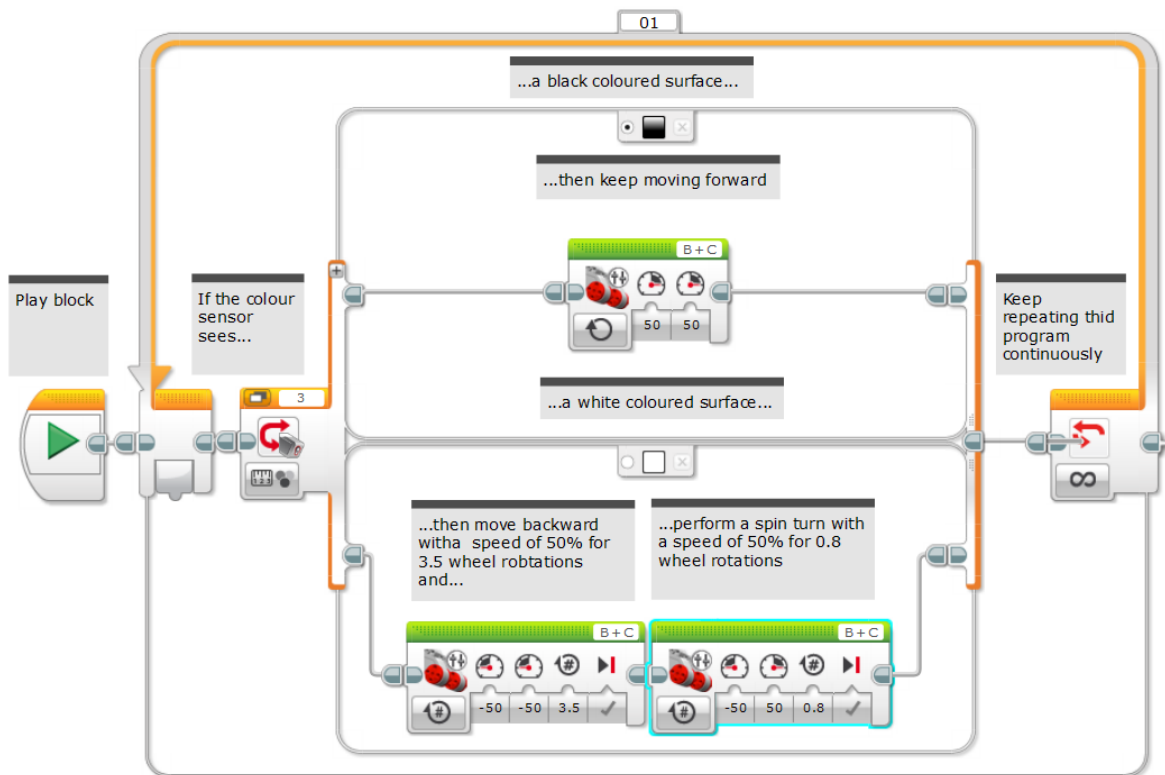
6. Select “*FIRST* Canada Beta Test: Cleanup Challenge” from the list of available challenges; then open and turn on your virtual brick.



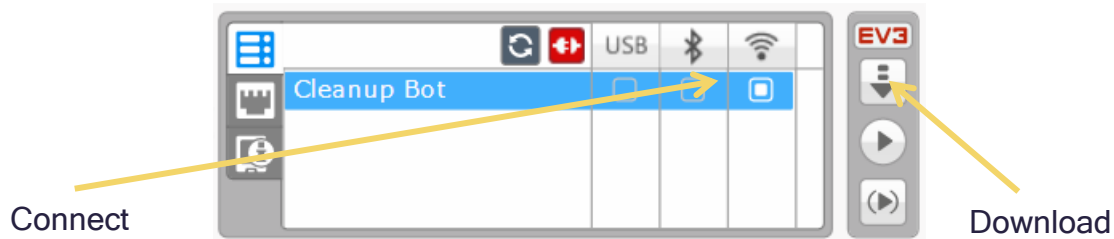
Create your Code

7. Return to or open the LEGO Mindstorms EV3 programming software and create a program to make the robot clear the structure without falling off the edge. Here is a sample program that uses Move Tank, Colour Sensor, Loop and Switch blocks to make the robot:

- move forward if the colour sensor detects a black surface
- back up for 3.5 wheel rotations if the colour sensor detects the white border
- perform a spin turn to the left for 0.8 wheel rotations
- repeat (or loop) these steps until the robot clears the structure and you press “Pause”

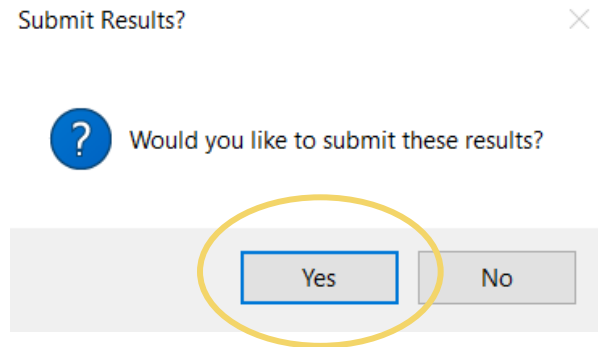


8. Connect to the virtual brick and download your program.



Submit Your Results

9. Return to the Virtual Robotics Toolkit and run the program. Once your robot has cleared the structure, you will have the option to submit your scores, which will be displayed on the leaderboard at www.virtualrobotgames.com.



10. You can also modify your program and repeat the challenge as many times as you like to try to improve your score. What if you added an ultrasonic sensor that could detect the distance between your robot and the structure?

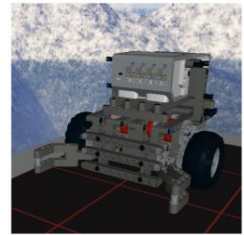
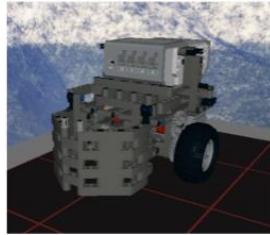
Congratulations! You have completed the Cleanup Challenge!
Read on for other challenges to complete!

MORE CHALLENGES

Customize the Robot

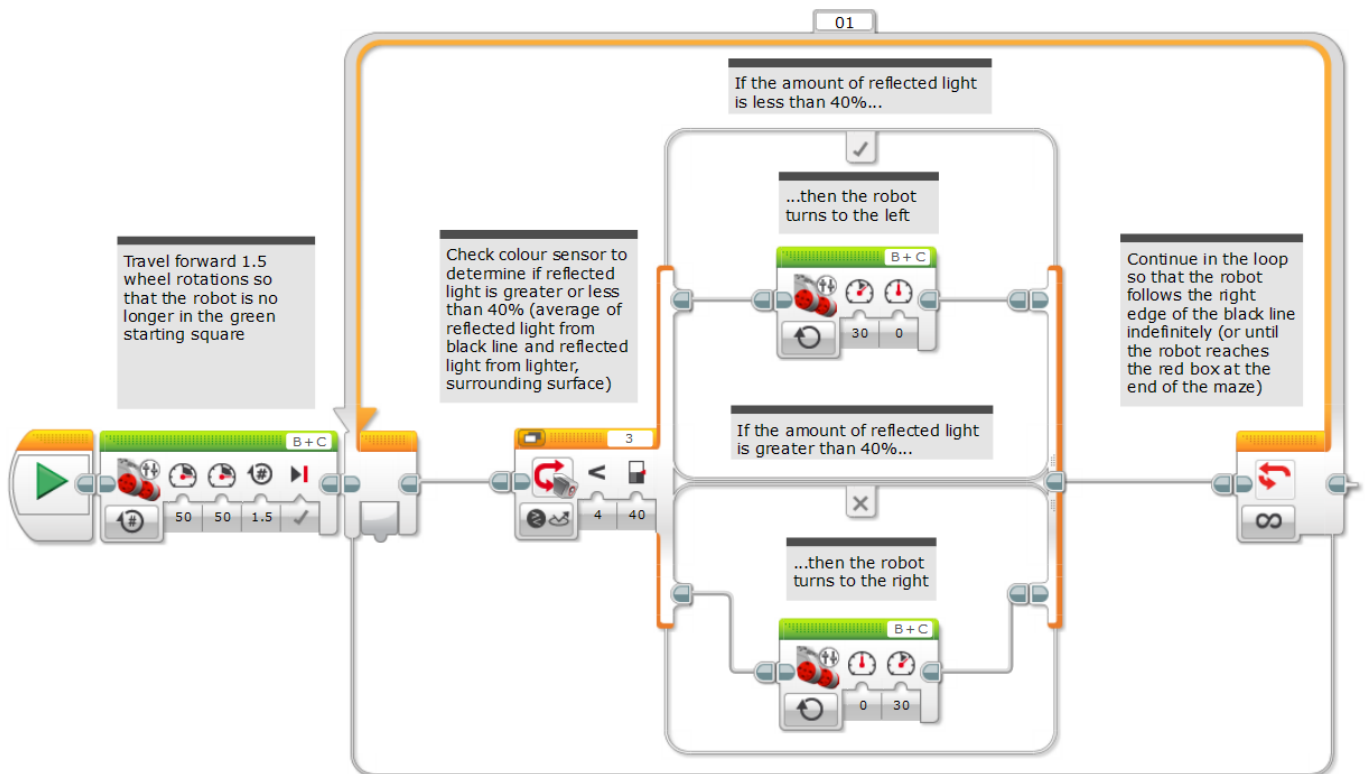
Repeat the Cleanup Challenge using the following attachments. Which attachment works best and can you design, import and test your own attachment using LEGO Digital Designer?

- Pointed Ram
- Flat Ram
- V-Shaped Shovel



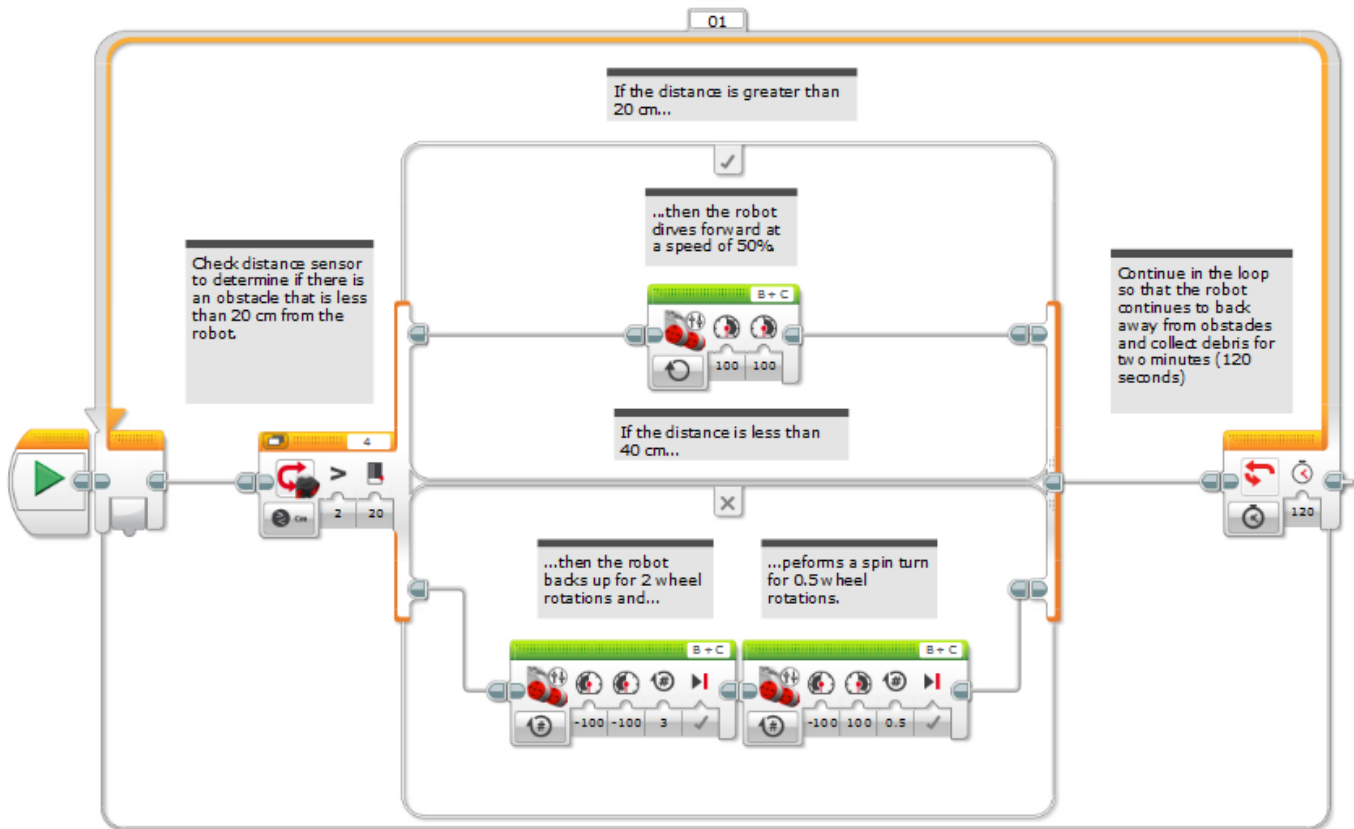
Line Follower

Use the LEGO Mindstorms EV3 software to program the robot to complete the maze. Here is a sample program that you can try to make your robot follow the line through the maze. How can you improve the program to decrease the time taken to complete the maze?



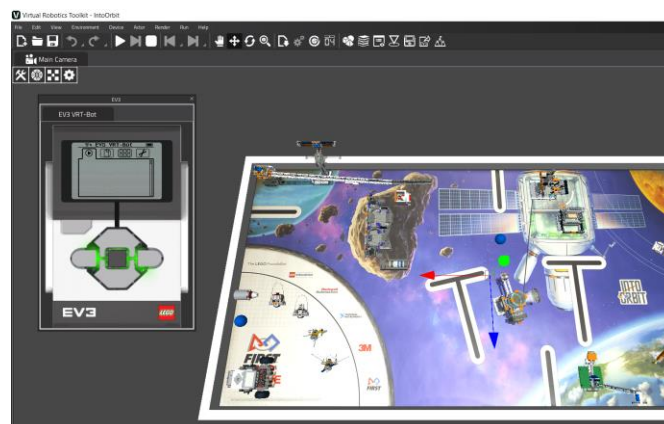
Robot Vacuum

Program the robot to clean up as much scattered LEGO as possible in two minutes. Here is a sample program that you can use to make your robot avoid obstacles as it vacuums the scattered LEGO. How can you improve the program to increase the amount of LEGO that the robot can clean up in two minutes?



FLL 2018 Into Orbit Challenge

Program the robot to complete missions and earn as many points as possible in 2.5 minutes. How can you modify the robot and program to improve your score?



ADDITIONAL RESOURCES

For more information about the Virtual Robotics Toolkit, download the Beginner's Guide at bit.ly/2Hc9WjD or view video tutorials on the Virtual Robotics YouTube Channel at www.youtube.com/user/VirtualRobotics.

For more information about the LEGO Mindstorms EV3 Hardware and Software, download the User Guide at bit.ly/2kKXn5O or go to the [Robot Educator](#) tutorials in the “Lobby” of the LEGO Mindstorms EV3 Programming Software.