CHAPTER 1
INTRODUCTION TO ROBOTS AND PROGRAMMING

Learning Objectives;

By the end of this Chapter, the students would be;

- Be introduced to robots,
- Learn about the basics of programming and its application with respect to robots,
- Learn about the LEGO Mindstorms EV3 kit,
- Understand the programming workflow of any project,
- Be able to identify the components of the LEGO Mindstorms EV3 kit and what can be built with it,
- Understand the importance and function of the Lego Mindstorms EV3 Brick, and
- Understand the importance and function of the Sensors and Motors.

Prerequisites

- A laptop or desktop computer.
- The Lego Mindstorms EV3 Kit

WHAT ARE ROBOTS?

Figure 1.0: A robot

A robot is a machine that has been programmed using a computer to perform complex tasks automatically. They carry out the tasks either by using the instructions (programmes) already uploaded in them or by an external device controller. A robot could be designed to carry out tasks like lifting a heavy load, using a vacuum cleaner to clean the floor, folding of fabric materials, fly fighter jets and many more. Generally, robots are created so as to make living easier. Robots can be designed in the form of a human but generally, a robot is designed in the form that makes it able to carry out the required task effectively.

In building a robot for a particular task, it is best to have an image or a sketch of how the end design of the robot should be. Having had a picture of the robots, the assembling of the robots would be done easily. As aforementioned earlier, robots carry out functions in two ways;

- The programme to carry out a specific function is completely uploaded into the robot controller panel, or
- The programme is uploaded into a device which will bse used to control the robot.

When using an external controlling device for the robot, the device and the robot must be connected in order to have a successful flow of transmission from the device to the robot and vise versa. The programmes are usually written in two separate ways;

1. The programme uploaded into the external controller is written to transmit signals.
2. The programme uploaded into the robot panel is written to accept and read the signal sent from the controller so as to carry out the desired function.

Programmes written for a robot are performed exactly as they have been written unless there is a bug (error) in the code written.

Building a robot with Lego Mindstorms EV3 basically involves 4 steps.

1. Build the robot.
2. Write the programme on a computer.
3. Download the programme into the robot.
4. Run the programme.

The branch of Technology that deals with the construction and operation of robots is known as **robotics.** Robots are sometimes designed with the idea of having to carry out human duties which seem almost impossible to do by a human. For instance, robots are built and operated to detect and deactivate bombs, fly fighter jets, go to a place with little or no air. Robots are also used in teaching STEM (Science, Technology, Engineering and Mathematics).

INTRODUCTION TO PROGRAMMING

What is a Programme?

Programmes are set of instructions that are written to a computer on how to perform a specific task. Programmes are written mainly by using a computer. The process of writing the programmes (instructions) on a computer is known as **Computer Programming** and these set of instructions is known as **Computer Programming Language.**

Computer Programming Language is the language the computer understands. For a computer to carry out a function successfully, the right programming language must be given to it. Just like humans, for a British man and an Asian man to communicate with each other without difficulty, they would either have to speak the generally accepted language, English Language or one of the both of them would have to speak the other person's language. The same goes for computer programming.

Programmes are basically instructions. So when programming a robot, the instructions given to it must be specific for the robot to understand. Take a look at this set of instructions (programmes) for my robot.
Assuming the name of my robot is GEEK.
Programme - GEEK, move forward and stop.
Trust me, GEEK will remain where it is.
WHY?
This is simply because the instructions given to it is confusing and not specific.
Let's take a look at another example.
Programme - GEEK, move forward for 5 seconds and stop.
This is a programme any robot would execute with ease. Remember, the instructions need to be specific. We will look into another example.

Different computer devices (smartphones, remote controlled toys, robots, smartwatches, washing machines) work based on the programming language which has been downloaded in them. There are various computer programming languages which the computer understands. These includes; Java

Programming Language, C++ Programming Language, C Programming Language, HTML (Hypertext Markup Language, Python.

Computer Programmes written and uploaded into a robot will work successfully if the programme is without bug (error).

For a programme written for a computer device to work successfully, there is a simple process which has to be followed.

Programming Workflow of any Project

The programming workflow of any project is carried out in 4 basic steps.

1. Create a programme.
2. Test and Run the programme.

   (The next 2 steps will be carried out **only** if the programme which was tested didn't run successfully)
3. Debugging i.e checking for errors in the programme.
4. Run the programme again.

THE LEGO MINDSTORMS EV3

Figure 1.1: Lego Mindstorms EV3

The Lego Mindstorms is a software programme produced for the development of robots based on Lego Building Blocks. Each Lego Mindstorms kit contains the Brick, sensors, motors and other Lego connecting blocks to create the mechanical system. The Lego MIndstorm EV3 Components can be set up in any way to look like a particular thing. That is, one could build any robot of one's own choice using the available components. Cars, bikes, trucks, animals, robocops are examples of robots that could be built. Your building ability will depend on your innovative skills. That is, your ability to build a desired kind of robot will depend on your ability to be creative using the Lego Mindstorms EV3 components.

There has been four generations (versions) of the Lego Mindstorms since its inception.

- The original Robotics Invention System
- The NXT
- The NXT 2.0
- The Lego Mindstorms EV3

There are two phases to building a successful robot with Lego Mindstorms EV3.

1. **The Hardware Phase:** The contains the EV3 building blocks (the brick, sensors, motors and other parts).
2. **The Software Phase:** This is the software which is used to programme the already built robot. The programme is written on this software and then uploaded to the robot for it to carry out the desired task.

The Lego Mindstorms EV3 Components

The Lego Mindstorms EV3 Components are found in the Kit pack. Below are various components found in the kit pack.

Section 1.3.1

- **<u>The Control Centre a.k.a The Brick</u>**

Figure 1.2: The Brick

The Brick is the most important component of the Lego Mindstorms EV3 because it is the central processing base of the Mindstorms. It is otherwise known as the brain.
Functions of the Brick is as follows:

- It sends programmed information to the motors.
- It receives information from the sensors.
- Plays sounds already programmed.

On the Brick is an LCD screen to display and buttons for navigating. There are also ports (alpha and numeric) on the Brick for the connection of the motors and sensors. A USB port is made available for the transfer of programmes from the computer to the Brick. Provided at the side of the Brick is an SD Card slot for more storage of programmes written on the computer.

- **<u>The Motors</u>**
  - **Large Motor**

Figure 1.3: Large Motor

    - Receives programmes from the Brick
    - Required for heavy duty.
    - Required for mobility.

  - **The Medium Motor**

Figure 1.4: Medium Motor

    - Receives programmes from the Brick
    - Required for light duty.
      NOT suitable for mobility.

- **<u>The Sensors</u>**
  - **The Colour Sensor**

Figure 1.5: Colour Sensor

    - Detects colour differences and sends the data to the Brick.
    - Emits a set of colour wavelengths. The colour which is not reflected determines the colour of the surface.

  - **The Touch Sensor**

Figure 1.6:Touch Sensor

- Sends information to the Brick based on the instruction (programme) given to it i.e when pressed, not pressed or bumped.
- Used to know when the robot has bumped into an object or surface.

- **The IR (Infrared) Sensor**

Figure 1.7: Infrared Sensor

- Detects proximity and sends information to the Brick.
- Receives signals from the **IR Beacon.**

- **The IR (Infrared) Beacon**

Figure 1.8: Infrared Beacon

- Used as a hand-held remote controller as it sends signals to the **IR Sensor.**

- **Gyro Sensor**

Figure 1.9: Gyro Sensor

- Detects the robots rotational motion and sends the data to the Brick.

- **The Connecting Blocks**

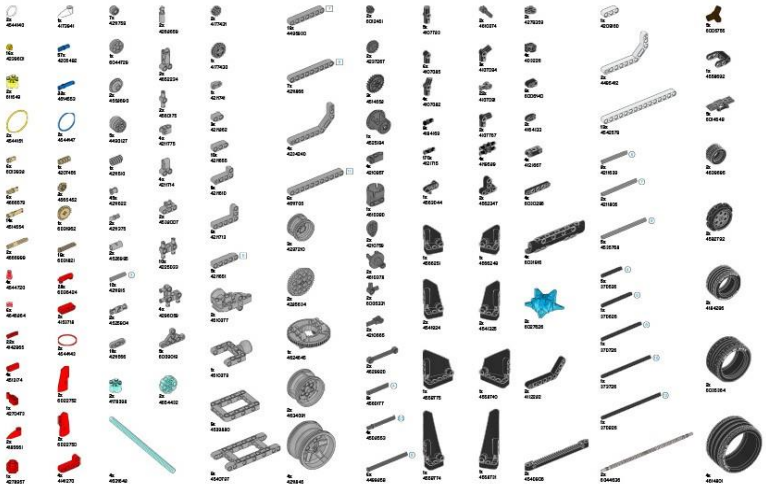

Figure 1.10: Lego Mingstorms EV3 Components

These are the components in the Lego Mindstorms EV3 that joins the motors and sensors to the Brick. The are used to aid mobility and structure.

Some steps have been put in place to build you to using the Lego EV3 components creatively.

- **Sketching**: It has been discovered over time that a designer always have sketch of what they have in mind to create. It is a good practice to always create a picture of what you want to create or design in your head (imagination). So in order to have an awesome robot as an end product of your work, it would be good to have a sketch of what your robot should look like.
- **Listing The Programmes**: The next thing to do now is to list out what you would like your robot to be able to do. Remember, your robot will only do things you programmed and downloaded successfully into the Brick.
- **Merging The Components**: Having listed all the programmes for your robot, the next thing is to get the Lego EV3 component (sensors, motors, large / medium motors) which is capable of carrying out the desired listed programmes.
- **Begin Construction**: Right now, it is time to start building your robot. Built your robot so that it looks like the picture of it you imagined and drew. You can get ideas from the previously built robots to assemble a particular part of your desired robot. Also, note that it is not a bad idea to edit your sketches and programmes as get new ideas while building.

NOTE: While building your robot, always have in mind the things you would like your robot to do in order to make sure that there will be no restriction(s) of a particular component to executing a particular task.

- **Programming**: Now that you have successfully built your robot to your taste and you are satisfied with it, it is now time to programme it to do the things you listed in the second step above.

With the above steps being followed, you would be proud of the kind of robot you would be able to build.

Chapter Project : Building a non-programmed TRACK3R

Now it is time to get to work. In this chapter, you are going to build the TRACK3R, but you will not be programming it because you are yet to understand the Lego Mindstorms EV3 Programming Software. You will be building the TRACK3R in this chapter. So from the programming manual for TRACK3R, follow the steps sequentially to build the TRACK3R.

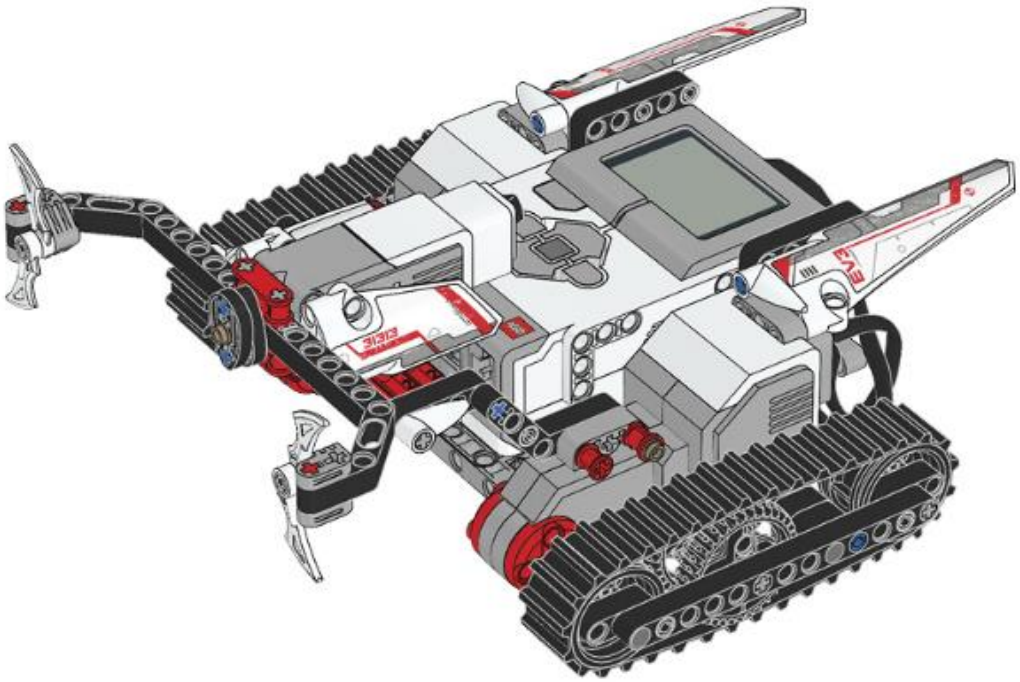

Figure 1.11: The TRACK3R

Summary Of Module One

In this chapter, you have learnt about robots and what programming is basically. You now understand how programming is related to robots. Programming has a workflow, which you now understand. You learnt the importance of debugging your programming commands.

You have been introduced into the Lego Mindstorms EV3 Kits. You can identify each component of the Lego EV3 kit. You now understand the importance and use of each component.

CHAPTER 2

INTRODUCTION TO LEGO MINDSTORMS EV3 SOFTWARE INTERFACE

Table of Contents

Chapter Project : Build and programme a TRACK3R

Chapter Objectives:

By the end of this Chapter, the students would be;

- Understand the importance of the Lego Mindstorms EV3 software
- Begin a new project
- Understand the functions of each part of the EV3 Programming Screen Overview;
    - The Menu,
    - The canvas,
    - The Pallete,
    - The Hardware, and
    - The Toolbar
- Understand the action and flow control blocks
- Upload and Run a programme on the LEGO EV3

Chapter Prerequisites

- The Lego Mindstorms EV3 software installed on a laptop or desktop computer
- A USB cable for transfer of the written programme

- Six (6) pieces of 1.5V battery to power the Brick.

THE LEGO MINDSTORMS EV3 SOFTWARE INTERFACE

Just as aforementioned in *Section 1.2* of the Chapter 1, the building and programming of a robot comes in two phases. The building of the robot is the hardware phase, while the programming of the robot is the software phase.

The Lego Mindstorms EV3 Software Interface *(see image below)* is the software you install on a PC (Personal Computer) used in writing the programme which the computer understands would then be uploaded on the robot for it to carry out the task. Every automated machine would first be built (hardware phase), then a suitable programme for the machine would be written on a computer and finally, the programme would be transferred to the already built machine to execute the desired duty.

To be able to launch the Lego MIndstorms EV3 Software on your PC, it is required that one would first have to install the software on one's PC. After successful installation of the software, an icon will appear on the background screen of the PC.

Figure 2.0: Lego Mindstorms EV3 icon

Double clicking on this icon will launch the software or one could also right click on the icon and then left click on the "Open" from the options that appears.

Once launched, the software pops up just the way it is in the image below.

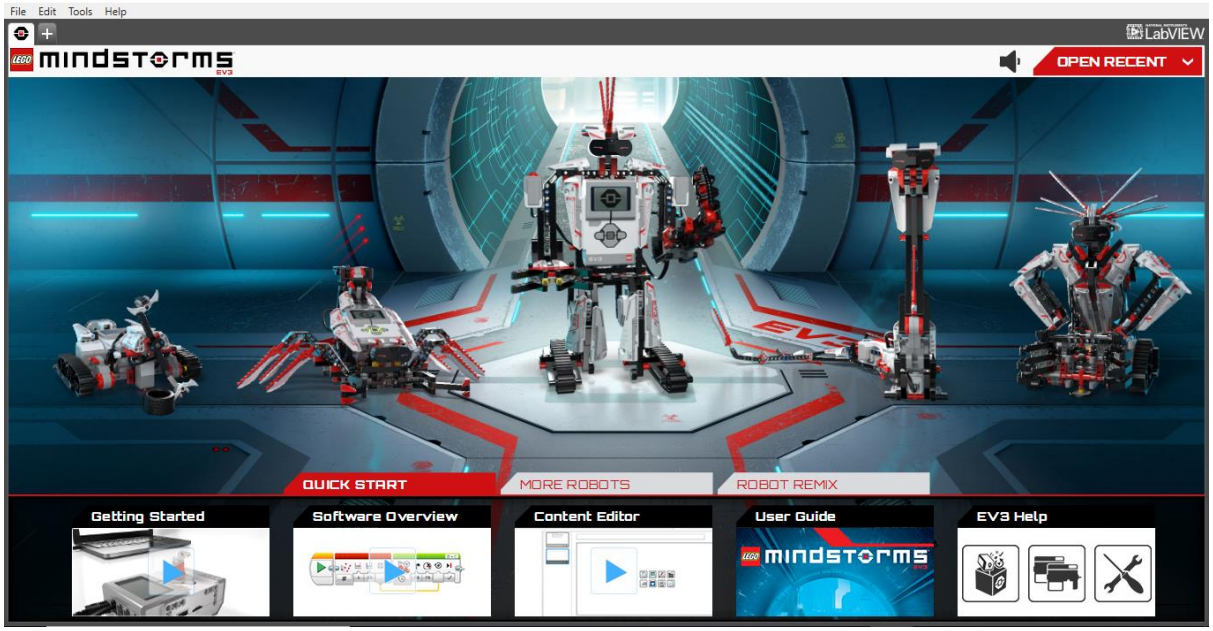

Figure 2.1: Lego Mindstorms EV3 Software Interface

There are different sections available in the software one could navigate to. Help materials (videos) have also been made available to help the user of the software understand how to use the software effectively.

The **QUICK START** Section contains 3 videos;

- Getting Started,
- Software Overview, and
- Content Editor.

Figure 2.2: Quick Start Assistance (Lego Mindstorms EV3)

Aside from the five robots, TRACK3R, SPIK3R, EV3RSTORM, R3PTAR and GRIPP3R which are already installed in the software, a section, **MORE ROBOTS,** on the software is provided for one to be able to download more robots to build and programme.

Figure 2.3: Getting more robots (Lego Mindstorms EV3)

Another section is the **ROBOT REMIX** which its subsections are used to redirect one to the Lego Mindstorms Official Website.

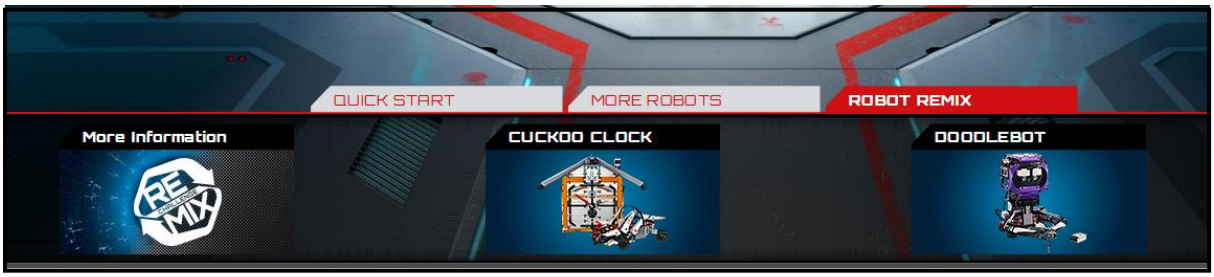

Figure 2.4: Redirecting to Lego Mindstorms Official Website

At the top left corner of the Software Interface are four sections; File, Edit, Tool, and Help. All four sections are useful in working on different projects.

BEGINNING A NEW PROJECT

There are two easy ways to navigate to begin a new project and start programming.

1. Click on the FILE. A drop down menu will display with different options. Click on “New Project”. The screen that displays will be the programming screen interface.

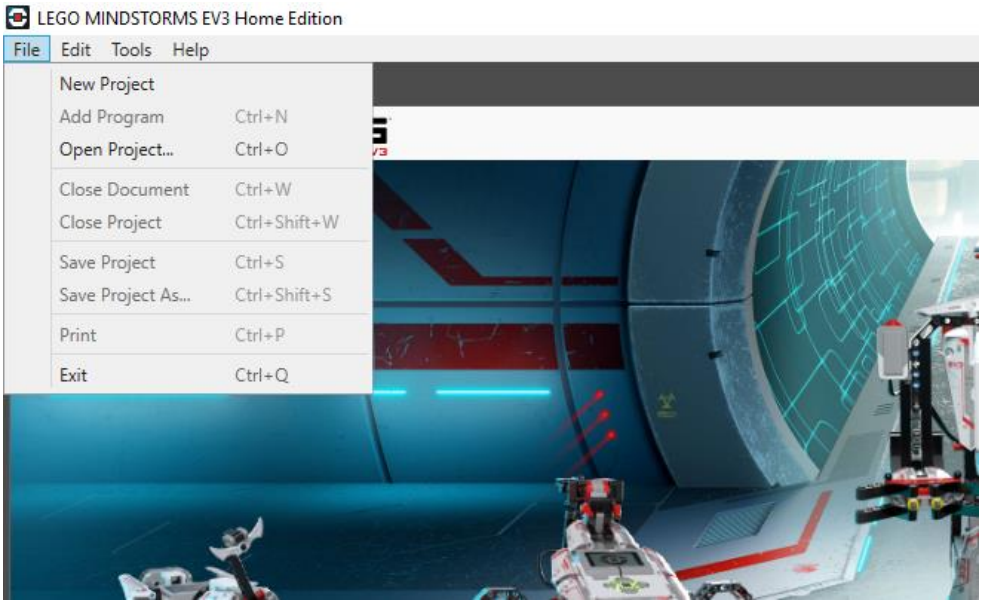

Figure 2.5: Navigating to New Project

2. Click on the **+** icon that is just next to the Lego Mindstorms EV3 icon at the top left corner of the screen.

Figure 2.6: Navigating to New Project

PROGRAMMING SCREEN OVERVIEW

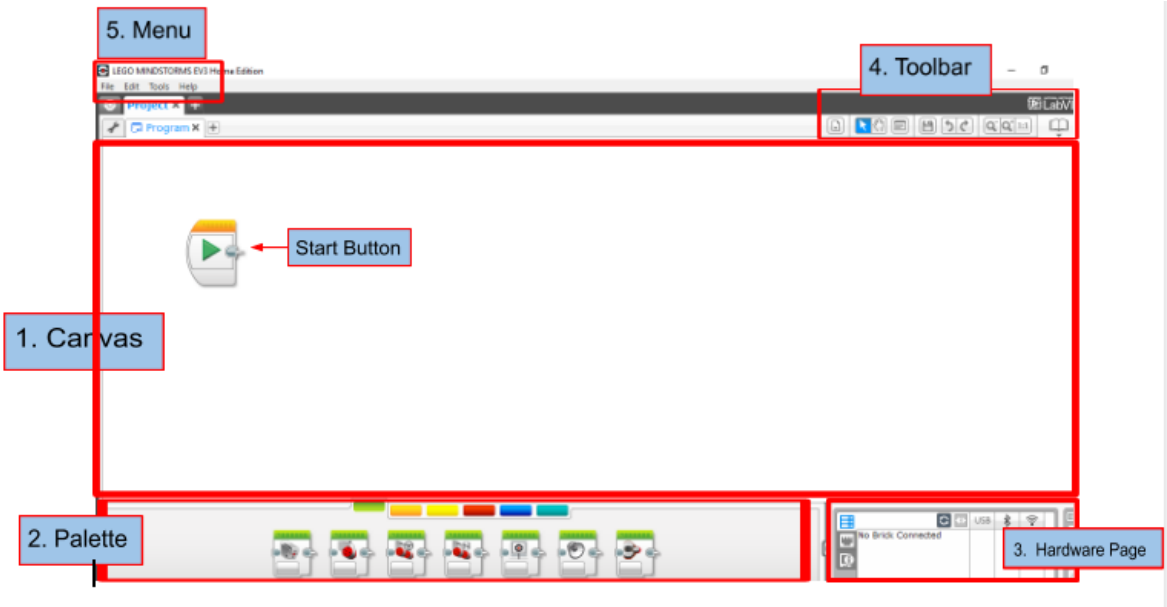

Figure 2.7: Programming screen overview

This is the software programming interface. Any task the Lego Mindstorms EV3 Robot execute is as a result of the programmes that has been written here and uploaded on the robot. This interface has 5 basic sections;

1. Canvas
2. Palette
3. Hardware Page
4. Toolbar
5. Menu

Each of these sections have their different uses and importance.

1. **The Canvas:** This section is the programming area.
    a. Programming blocks from the Palette are joined in the this area.
    b. A Flow Block Start Button is always on the canvas to begin programming b default.
2. **The Palette:** This section contains the programming blocks used in giving the robots instructions. Each colour of the Palette has its function.
    a. Green: Action
        i. Used to programme the movements,sounds and display capabilities.
    b. Orange: Flow Control
        i. Used to enhance the capabilities of other blocks.
        ii. The blocks in this section cannot be used alone.
    c. Yellow: Sensor
        i. Used to control the sensors connected to the Brick.
        ii. How the robot behaves when it senses a thing is programmed here.
    d. Red: Data Operations
        i. Used to manipulate the data that the sensors and other blocks are collecting.
    e. Blue: Advanced
    f. Cyan: My Blocks
3. **Hardware Page:** The Brick information is displayed here and this is the area for downloading the programmes into the Brick.

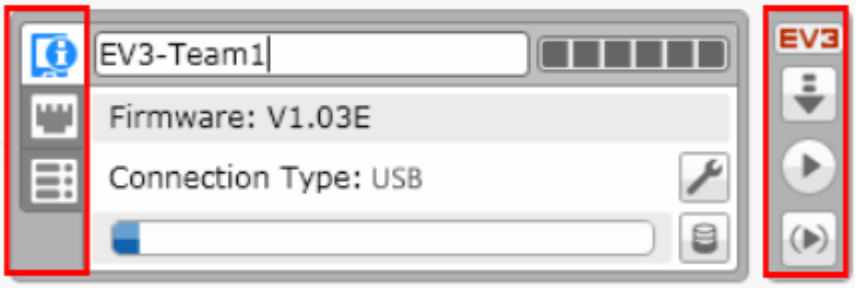

Figure 2.8: Hardware page

The three tabs on the left hand side of the Hardware Page are;

- **Brick Information:** This section shows the general information of the Brick. The Version, battery level, name (It is possible to give your bot a name. Cool right?).
- **Port View:** When the Brick is turned on and connected, clicking on this port displays the status of the Motors and Sensors connected to the Brick via the Connecting Ports on the Brick.
- **Available Brick:**

The three tabs on the right hand side of the Hardware Page are;

- **Download:** This tab is clicked to **only** download the programmes into the robot.
- **Download and Run:** Clicking on this tab will download the programme into the robot and immediately run the programme once the programme has downloaded successfully.
- **Run Selected:** When the Brick is turned on and connected, clicking on this tab will run a specified (highlighted) blocks or set of blocks. In the process, the highlighted programmes are downloaded into the Brick. This tab is used mostly to see if a particular programmes would run successfully.

4. Toolbar: This is the section that is used to control the canvas area.

5. Menu: This section is used to save projects, open projects and do other simple edits on your project.

PROGRAMMING A ROBOT

The system of programming used in Lego Mindstorms EV3 is known as a Drag and Drop System of Programming. It is also said to be a Command System of Programming. That is, rather than writing a code for the robot to follow, the robots are given commands to follow. For instance, a command could

be given to the robot to "*turn 90 degrees to the left", "say hello", "roll tires for 5 seconds and stop then say yes",* and so on.

The commands used Lego EV3 are found in the Palette. The Start Button begins every command programme given to the robot. Every other command is dragged from the Palette section and dropped according to how the programmer wants to command the bot. The image below is an insight to how the programming of Lego Mindstorms EV3 works.

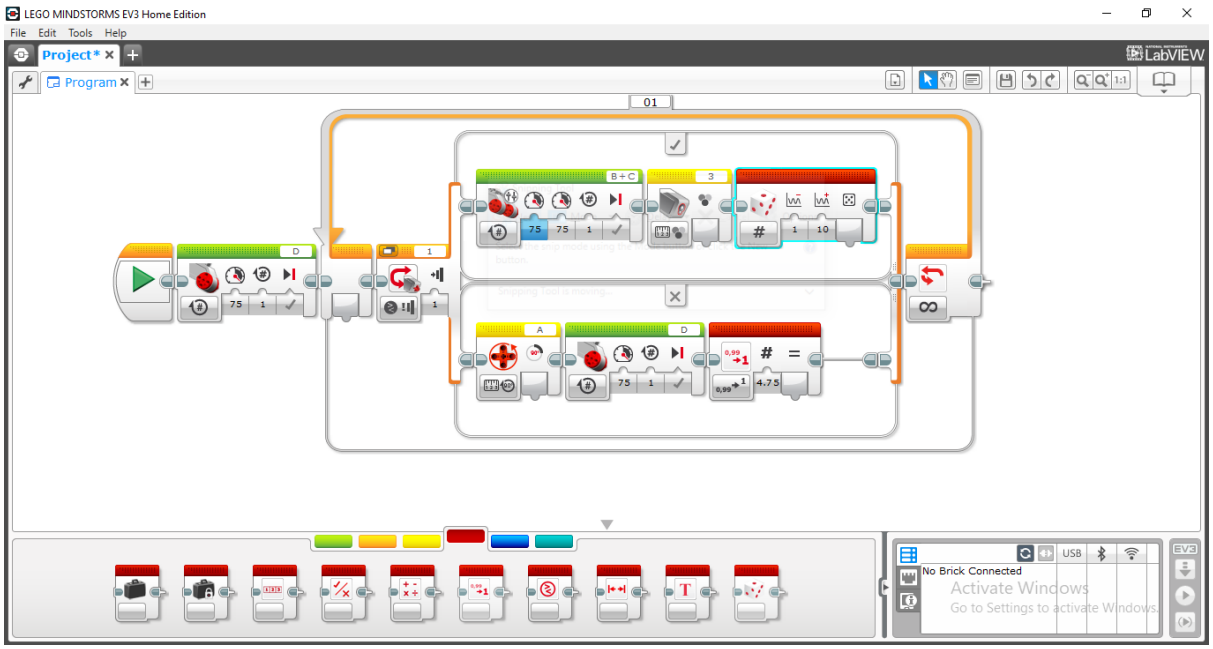

Figure 2.9: Programming screen Overview (Lego Mindstorms EV3)

wSection 2.4.1

The Action Blocks: The Action Block is more or less the most important of all the blocks in the Palette. There wouldn't be much excitement if a person builds a robot and he or she is not able to make it move or pick up an object. The Action Block helps in executing both tasks and more. There are different Action Blocks in the Palette.

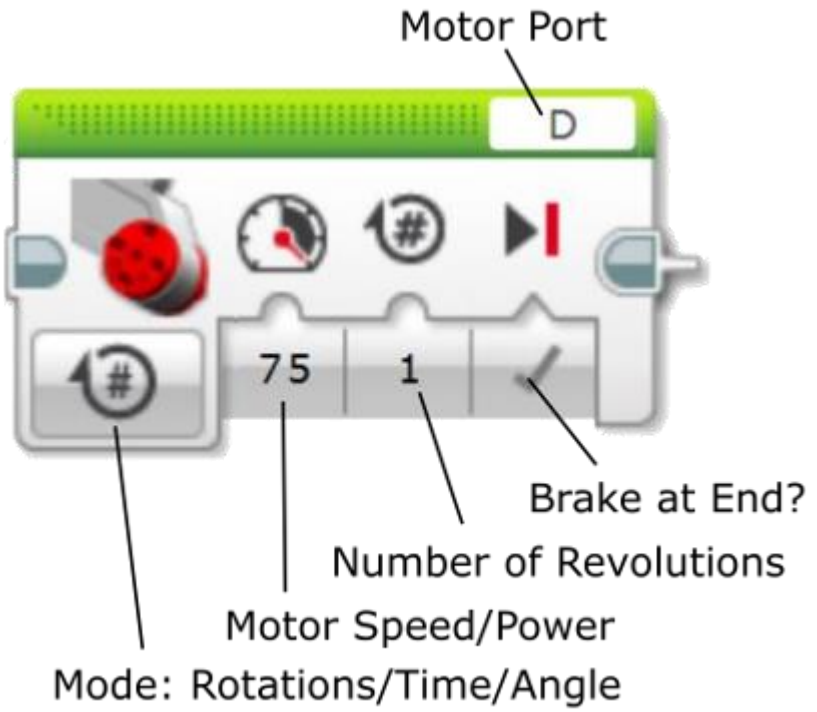

Figure 2.10: Parts of EV3 programming block

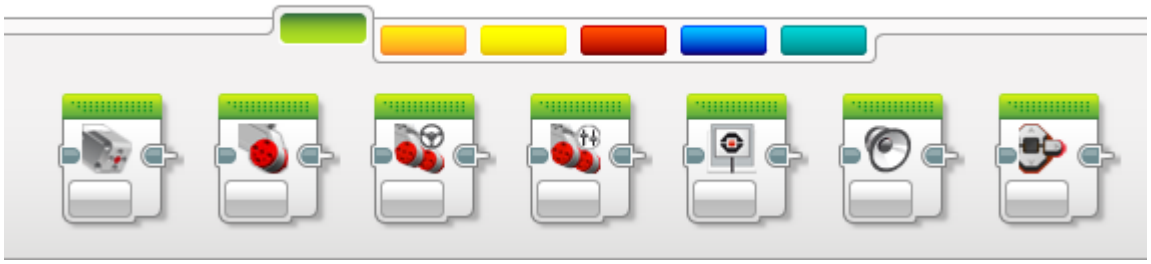

Figure 2.11: Action Block Palette

The available blocks in the Action Block Palette are;

(In order from left to right)

- Medium Motor
- Large Motor
- Move Steering
- Move Tank
- Display
- Sound
- Brick Status Light

Now let us go through on how to make use of each.

Medium Motor: This block is used to control the medium. The image below shows that;

- The Medium Motor is connected to Port A of the Brick.
- The mode is set in “On for rotations”.
- The motor has its power set at 75.
- The rotation is set to 1.
- It is to brake after the rotation.

NOTE: Your programme will not work if you do not select the right port your motor is connected to on the Brick.

Figure 2.11.1: Medium Motor

Large Motor: This used to control the Large Motor. The image below shows that;

- The mode has been set to “on for degree”.
- The motor is to turn for 360 degrees.

Figure 2.11.2: Large Motor Block

Move Steering: This block is used in the same way with the Large Block except that it is used to control two Large Blocks at a time. The image shows;

- The port A and C are selected.
- The mode is set to “on for degree”.
- The direction is forward.
- The power is set at 75.
- The motor is to turn for 360 degrees.
- It is to brake after the rotation.

Always remember to select the two correct ports when using this block.

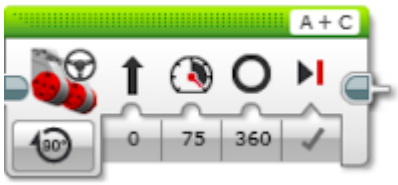

Figure 2.11.3: Move Steering Block

Move Tank: This block has the same functions as the Large Motor while operating two motors. Alternative power of the speeds results in the motors moving at different speeds.

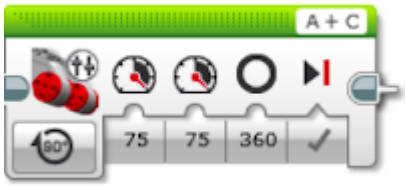

Figure 2.11.4: Move Tank Block

Display: This block displays information on the screen of the brick. Such information could be in text form, shapes or images. In this block;

- The mode selector is used to select a mode from Text, Shape, Image Reset Screen.
- The port selector is instead used to select files.
- The **X** and **Y** values are used to select the vertical and horizontal positons.

Figure 2.11.5: Display Block

Sound: This block has the capability to play a file, a tone a note, or just make the sound stop altogether. All depending on the mode selected. A file can also be picked from the the port selector option.

Figure 2.11.6: Sound Block

The Flow Control Blocks: The Flow Control Block is basically used to control other blocks and the Brick.

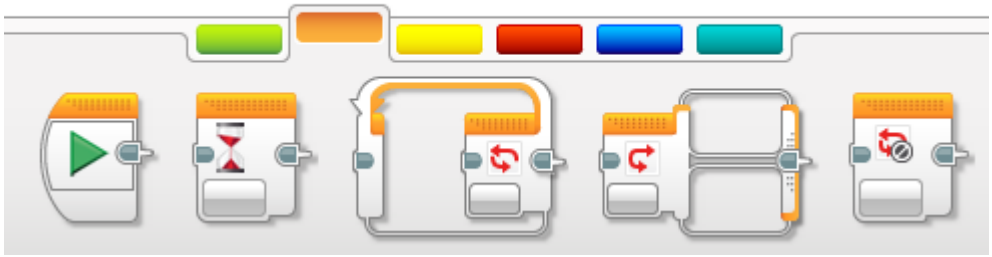

Figure 2.12: Flow Control Block Palette

(In order from left to right)

- Start
- Wait
- Loop
- Switch
- Loop Interrupt

Start: This block is used to begin any programme on the canvas of the programming screen. Without this block, no other block will run.

Figure 2.12.1: Start Block

Wait: This block is used to make your programme wait for a particular thing before continuing with the next connected block. The Wait Block could be used to wait on varieties of things depending on the mode selected.

Figure 2.12.2: Wait Block

Loop: This block is used to repeat the blocks that has been placed inside it until a certain condition is met. It is essentially a repeat block.

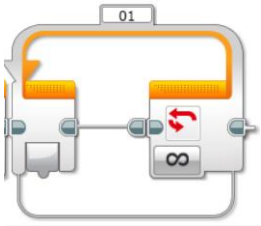

Figure 2.12.3: Loop Block

Switch: This block is a container that can contain two or more programming in a case. This block is used to run two different programmes when a certain condition is met. Only one cas will run each time the switch is executed.

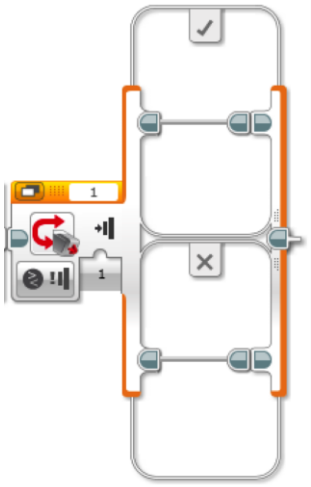

Figure 2.12.4: Switch Block

Loop Interrupt: This block brings all programme in a Loop Block end. The programme blocks placed after this Loop Interrupt Blocks begins to run.

Figure 2.12.5: Loop Interrupt Block

Section 2.5

DOWNLOADING AND RUNNING A PROGRAM

Once a programmer is satisfied with the programme he or she has arranged on the canvas of the Lego Mindstorms EV3 Programming Interface, what is left to do is download the programme into the robot for it to execute the programme. If the programme doesn't run as the programmer wishes, it means there is a bug in the command setup. The programmer would therefore have to debug (search for the error) the programme and download again. The robot will execute any correctly written command successfully.

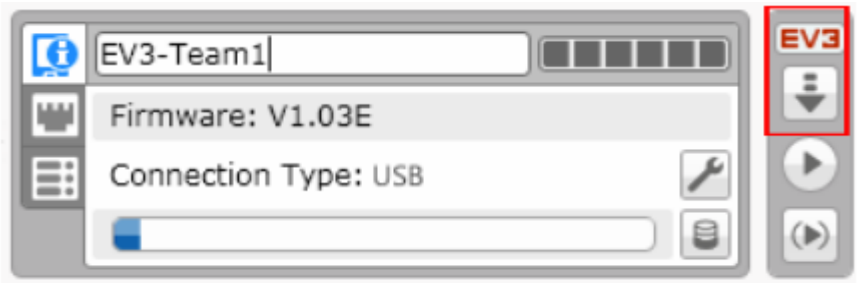

Figure 2.13: Downloading a programme

The download tab is used to download the command programme into the Brick of the robot.

NOTE: The Brick will have to be turned on and connected to the computer where the programme will be downloaded from via the Universal Serial Bus (USB) Cable provided in the Lego Mindstorms EV3 Kit Pack.

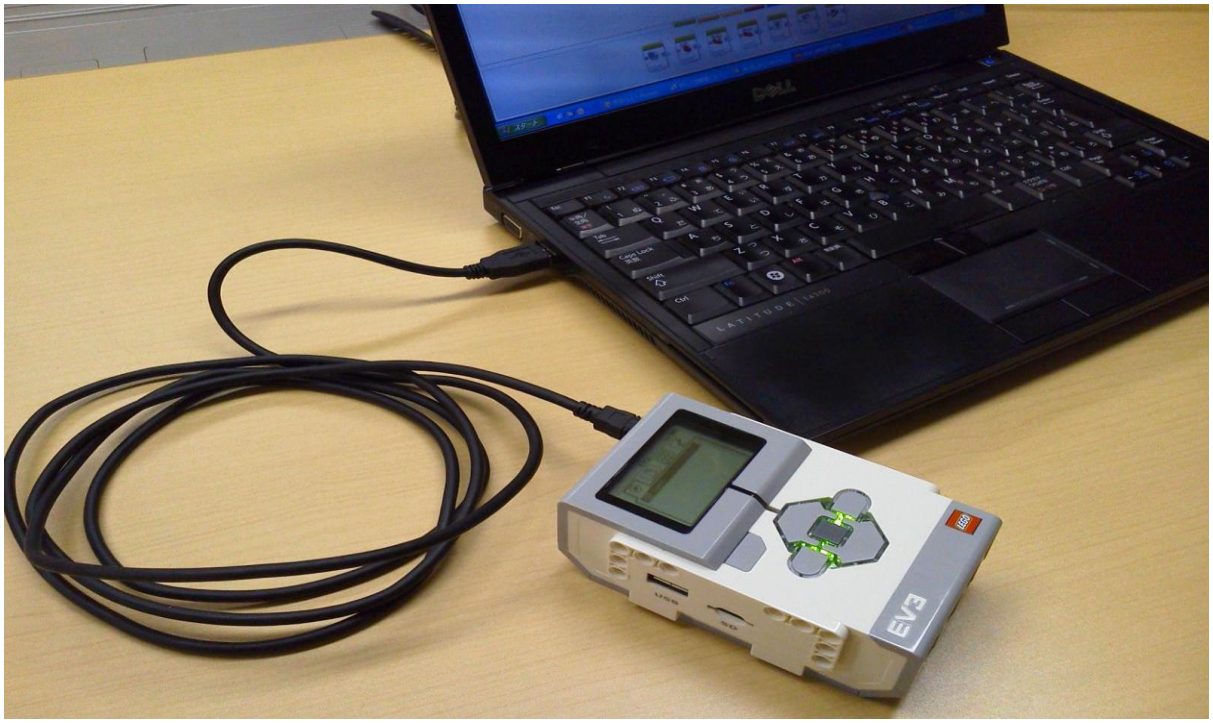

Figure 2.14: Connecting a Brick to a computer

CHAPTER PROJECT: Using the Action and Flow Control Blocks.

Now that you have learnt the basics of how to programme your Lego Mindstorms EV3 robot , in this chapter you will be programming the robot to do different things. Let us go through some programmes for your robot. Remember, these programmes are just to make you understand the concept of programming. You can always edit and modify your own programme to the way you would like it.

In this project, you will learn to use the Action and Flow Control Blocks by basically programming the GRIPP3R. Let us get going.

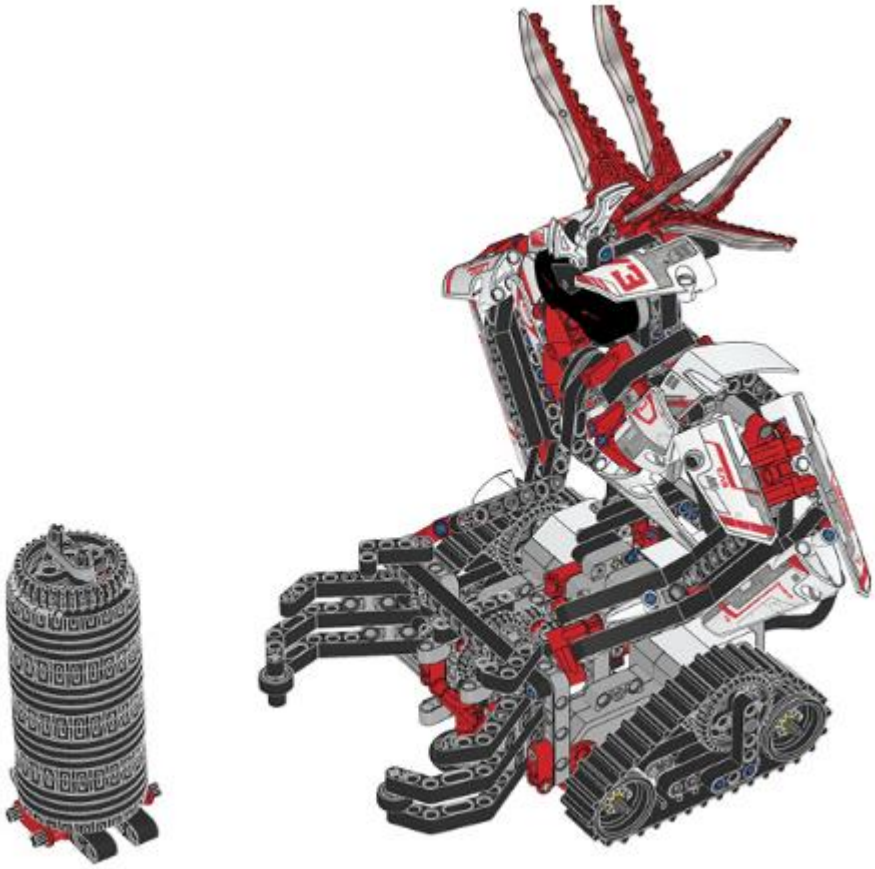

Figure 2.15: The GRIPP3R

Once you finished building the GRIPP3R, launch the Lego Mindstorms EV3 Software on your computer. Navigate to the programming software and follow the steps below to programme the robot.

First, drag and drop the Loop block from the Flow Control Palette. Then drag and drop 3 Medium Motor Blocks in the Loop Block as shown in the image below. This is essentially to give the Medium Motor task to do.

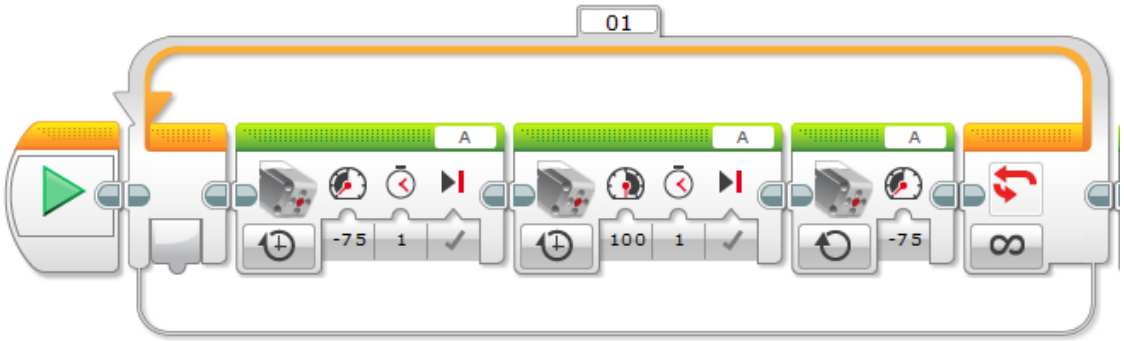

Figure 2.16: Programming a robot

Remember you could use vaalues different from the one used in the image.

Next, add the next two blocks as shown in the image below and input the values correctly. The first block is to make the two Large Motors move forward with a power of 75. While the second block will put the bloxks off.

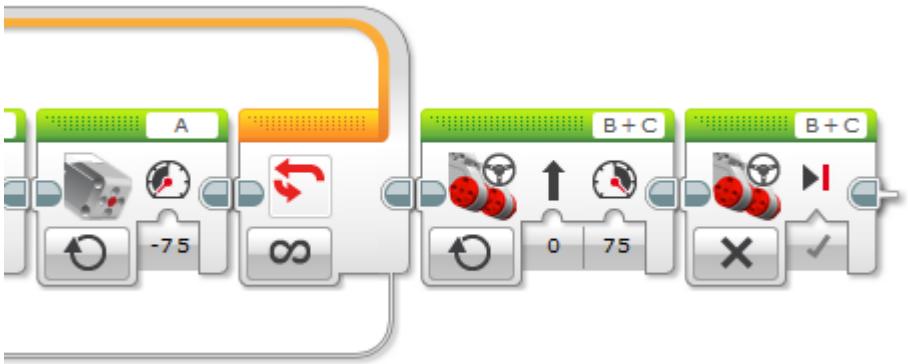

Figure 2.17: Programming a robot

Now add the two blocks as shown in the image below. The first block will make the robot do a **U** turn while the other block will make the robot move forward with a power of 75.

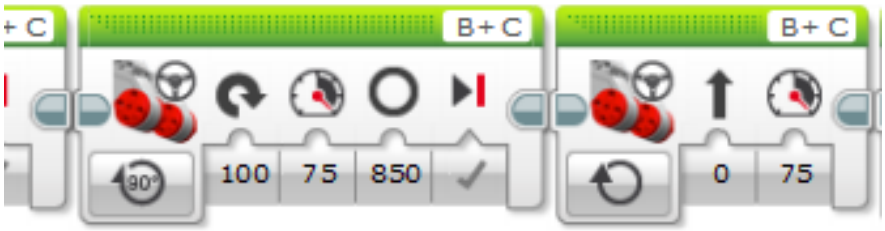

Figure 2.18: Programming a robot

Finally, let us end our programming by stopping the Large Motors. Add the block shown in the image below.

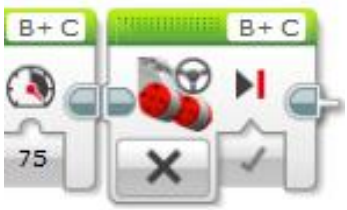

Figure 2.19: Programming a robot

Make sure the ports are selected correctly. After dropping your codes and you are satisfied with how it is, use the USB cable to connect the Brick to your computer and download your programme to the Brick.

NOTE: It would be a good practice to highlight a few blocks and run it to see it will run as you would want it to. If it doesn't, modify it and try again. If it does, then download your programme, disconnect the USB cable, place the robot on a flat surface and run the programme.

Congratulations on programming your first robot.

Summary Of Module Two

This chapter has introduced you to the software phase of the Lego Mindstorms EV3. That is, you have been introduced into using the Lego Mindstorms EV3 software. The different parts of the software have been introduced to you and you can identify each part.

Emphasis were made on how to use the Action and Flow Control Block from the Block Palette. You now understand how programming a robot works. You learnt that programming a robot involves giving the robot specific commands.

You have also learnt how to be creative in;

- building your robots,
- programming any robot of your choice, and
- downloading the programmes into the Brick of the robot.

CHAPTER 3

SENSING

Table of Contents

Learning Objectives;

In this chapter, the students would:

- **Understand how to program their robots using sensors.**
- **Understand how the Lego Mindstorm EV3 IR (Infrared) Sensor and Beacon works.**

.Chapter Prerequisites

- **A Completely built Lego Mindstorm EV3 Robot**
- **All the sensors present in the LEGO EV3 kit pack**
- **A laptop or desktop computer with the EV3 software installed on it**

SENSORS

The production and usage of sensors in technology has brought about a major breakthrough in the production of robots. With sensors, machines are able to come alive and behave like humans. Surprised right? To understand this, you will need to understand what sensors are.

A sensor is a device with the ability to detect changes in the environment and send data to the processing unit for the data to be processed. A sensor cannot be used alone. It is always connected to an electronic device. There have been lots of production and modification of sensors over time. Let's go through some examples: Imaging walking into a company. As you approach the door, it automatically opens for you to walk through. Anyone who has very little or no knowledge about technology and sensor might think of it as something supernatural, but it isn't. The door opened because of the sensor which has been installed there to work in connection to the door. Different kinds of sensors could have been used. It could be that there was face detection sensor installed there or a pressure plate sensor which made the door open as the human face was detected or as the weight of the human was detected once he or she stepped on the pressure plate sensor. There are various types of sensors present today. There is the fingerprint sensor which detects fingerprint, the heat sensor which detects increase in temperature, light sensor which detects the change in the brightness of an environment, the motion sensor which detects movement of a person or object and many others.

HOW DOES IT WORK?

As aforementioned earlier, a sensor basically detects changes in the environment. You might wonder how and why a machine reacts to what its sensor has detected. Here's what happens.

Let's use the fingerprint sensor which is installed in almost all modern mobile phones for example. When the owner of a phone has activated the fingerprint lock mode on his or her phone and the phone is locked. While activating the lock mode, data (finger print) from the owner is collected by the sensor and sent to the processing unit where it is stored. After a while, if he or she decides to unlock the phone using his or her finger print, he or she would have to place the finger on the sensor. Now the sensor reads and collects the data from the finger and sends to the processing unit. The processing units processes the data by comparing it with the previously stored data. If they are the same, the phone would be unlocked, but if the data collected is different from the one stored, there would be an error message appearing on the screen of your device.

This process seems like it would take forever to go to completion. It is not so. All these happens within a very short amount of time. Less than 2 seconds. This is because it is a machine and machines are fast and effective.

EV3 Data Wires

Data wires are wires used to input values or output values to some EV3 blocks. Just as humans have sensory nerves which transfers information detected to the brain for processing, the data wires in Lego Mindstorms EV3 are used to transmit information (data) from where they are created to where they will be used or are needed.

SENSOR PALETTE

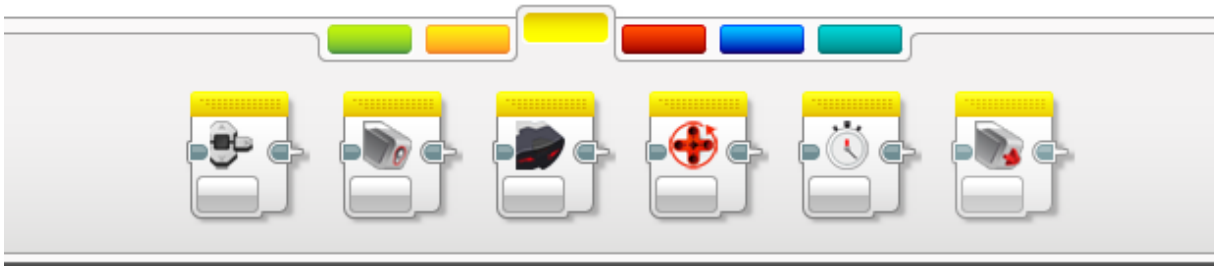

Figure 3.0; Senor Block Palette

(In order from left to right)

- Brick Buttons
- Color Sensor
- Infrared Sensor
- Motor Rotation
- Timer
- Touch Sensor

COLOUR SENSOR

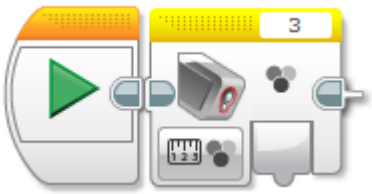

Figure 3.1; Colour Sensor

The Colour Sensor which is also known as a Light Sensor is used to detect colours or the intensity of light. There are different modes on how this particular sensor work.

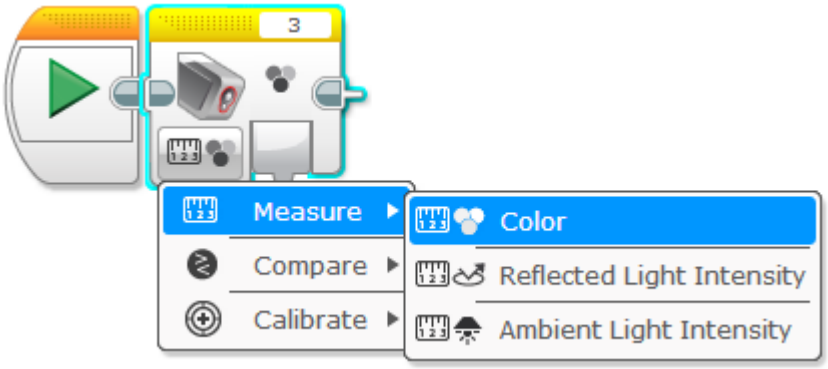

Figure 3.2; Colour sensor mode

Clicking on the mode gives this drop down menu options, Measure, Compare and Calibrate. We will take out time to explain each. Measure and Compare have the same sub options. So they will be discussed together.

Measure and Compare: These modes have the same sub options;

Colour: This is used to make the sensor detect a particular colour. Each colour is assigned a number from 1 - 7. That is, this sensor can detect 7 different colours.

Reflected Light Intensity: When this is used, it makes the Colour Sensor emit its own light and then checks to see what percentage of that light is going to bounce back. That is how it tells how it tells the brightness or darkness of whatever it is looking at.

Ambient Light Intensity: this is similar to the Reflected Light Intensity, but in this case, the sensor does not emit its own light. Instead it is looking for the light that is being directed at it. This can be used to determine the brightness of a light source.

Calibrate:

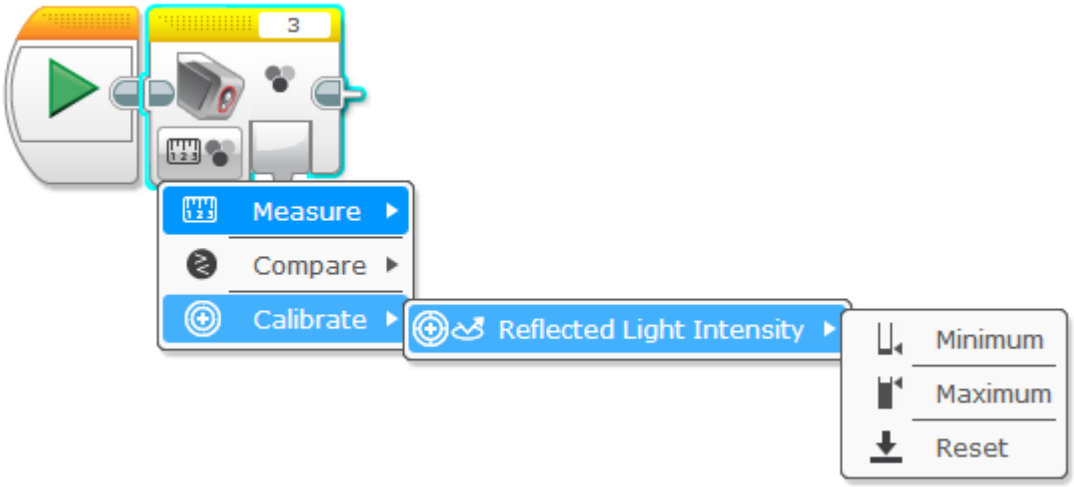

Figure 3.3; Colour Sensor Mode

This can only be used with Reflected Light Intensity. It has 3 other sub menu, the MINIMUM and MAXIMUM is used to set the minimum and maximum percentage value you want the sensor to look at. RESET is used to set the calibrator settings back to factory default.

Programming With A Light Sensor

Do you know that it is possible to build a robot that would follow a particular line irrespective of the length of the line? It might look like rocket science, but this can be done by following a few simple steps.

Build a robot of your choice, then drag and drop your EV3 blocks as shown in the image below.

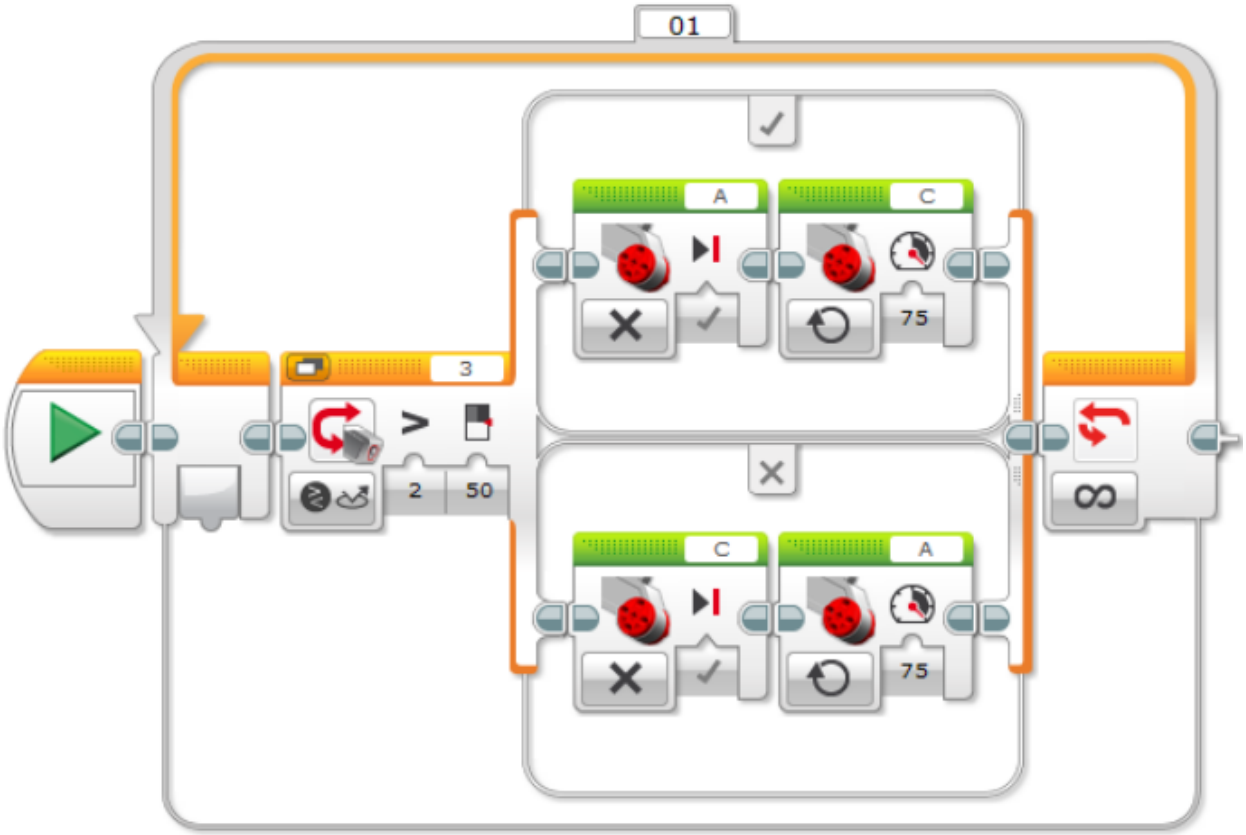

Figure 3.4; Programming with a colour sensor

The code above switches between the left and right motor of the robot, depending on whether the colour sensor sees the line or not. In the code above, the Large Motor connected to port A is the left motor while the Large Motor connected to port C is the right motor. When the colour sensor sees the line, the right motor (Large Motor C) stops while the left motor (Large Motor A) starts turning. Also, when the colour sensor does not see the line, the left motor stops while the right motor starts turning. This then makes the robot to turn towards the line while moving forward.

Easy right? Yeah! That is how programming a robot can be. All that is required is your ability to think about it and arrange the blocks to give you your desired result. Go ahead to modify the code to your taste.

TOUCH SENSOR

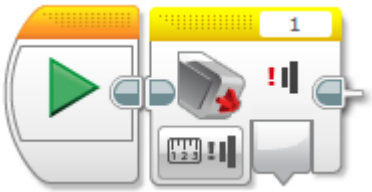

Figure 3.5; Touch Sensor

The Touch Sensor is used to tell the robot what to do when it has been touched, has not been touched or bumped. It also has different modes, MEASURE and COMPARE. Both having the same sub menu, STATE.

In the next few steps, we will programme a robot using a touch sensor which will act as a power button. That is, the program will be arranged in a way so that the robot will move when the touch sensor is pressed and would stop when the touch sensor is released.

First, build your desired robot and add these steps.

- Insert a Switch block and set the mode to touch sensor.

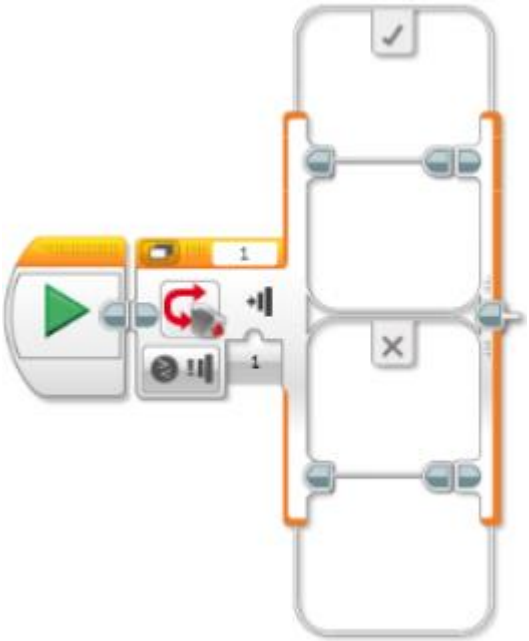

Figure 3.6; Programming with a Touch Sensor

- Insert a Move block into each container of the Switch block. Configure one motor to move continuously and set the other motor block to stop as shown in the image below.

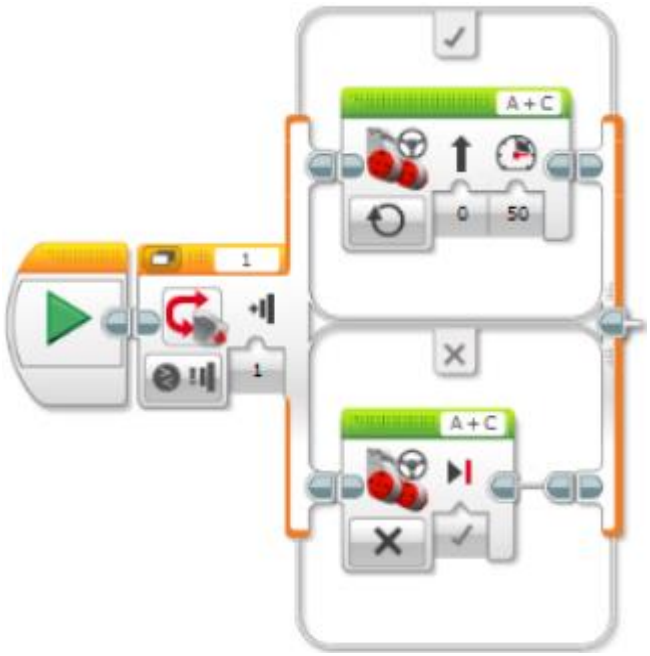

Figure 3.7; Programming with a Touch Sensor

- Place the Switch block into a Loop block.

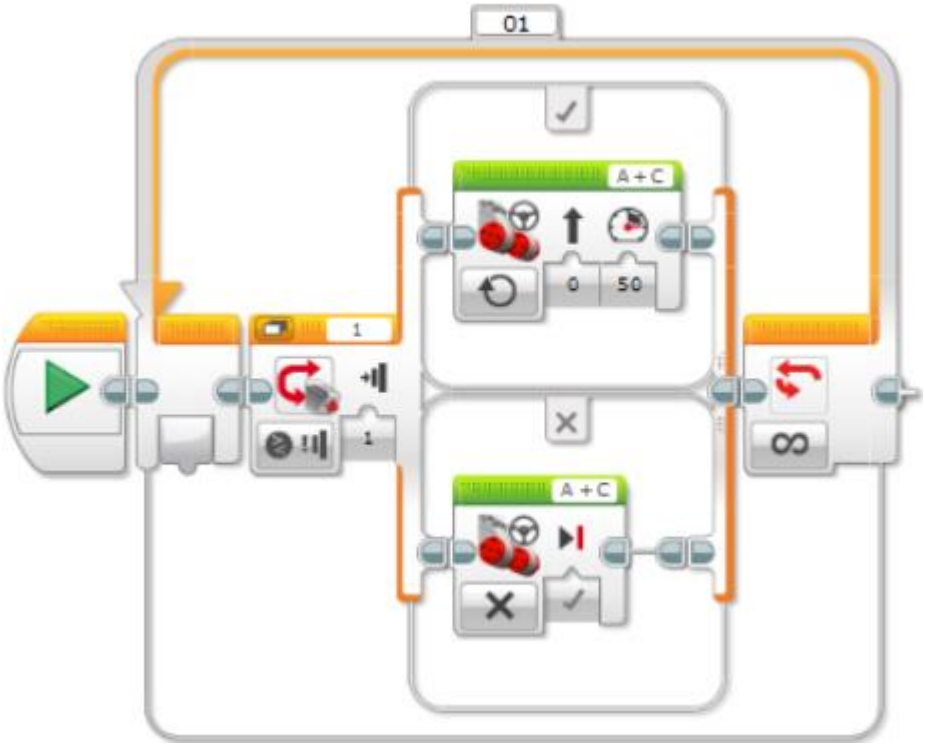

Figure 3.8; Programming with a Touch Sensor

This is quite simple, isn't it?

IR (INFRARED) SENSOR

The Infrared Sensor can measure distance or detect signals that are sent to it from the infrared Beacon. This sensor has different modes.

MEASURE: This is used to take the value that is being read on the sensor. It has 3 sub menu,

- **Proximity**: Used to determine the distance between the sensor and an object in percentage.
- **Beacon**: Used to detect beacon.
- **Remote**: Used when desired to be used as a remote control.

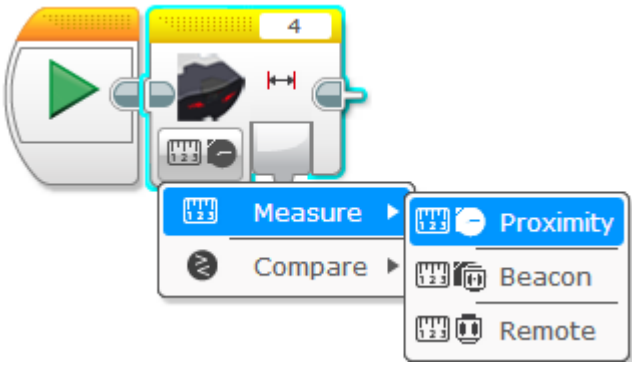

Figure 3.9; Infrared Sensor

COMPARE: This is used to compare the specifications you set on the sensor to what the sensor reads. This gives a TRUE or FALSE / YES or NO output from the data wire. It has 4 sub menu;

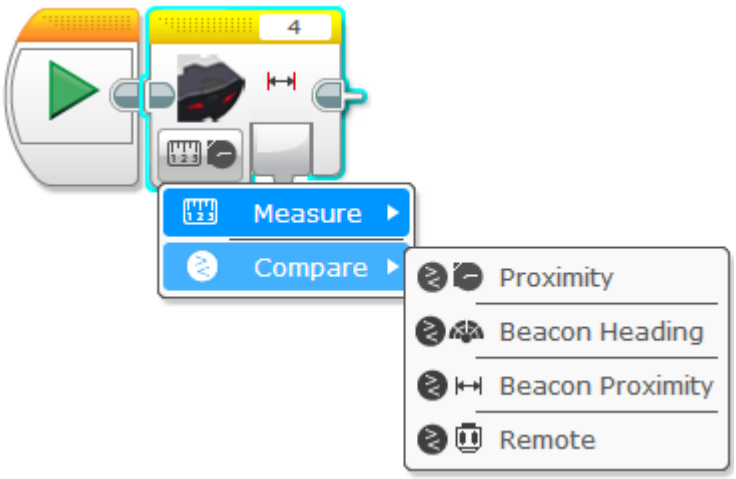

Figure 3.10; Infrared Sensor mode

- **Proximity**: Used to compare the proximity you set to what the sensor reads.
- **Beacon Heading**: Used to compare the position of the beacon to what the sensor reads. It has a range of -25 to +25. It reads;
    - 0 when the beacon is directly in front of the sensor,
    - -25 when the beacon is to the left of the sensor, and
    - +25 when the beacon is to the right of the sensor.

- **Beacon Proximity**: Used to compare the distance of the sensor to the beacon.
- **Remote**: Used for comparing the remote specifications you set to the readings from the sensor.

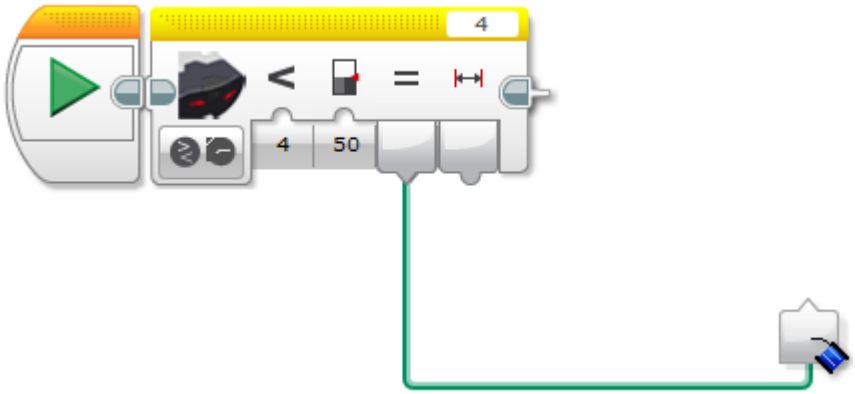

Figure 3.11; Infrared Sensor data wire

IR (INFRARED) BEACON

The Infrared (IR) beacon is an infrared transmitter, and can be used in beacon or remote mode.

- **Beacon mode** – In this mode, the beacon transmits an infrared signal continuously until you press the beacon mode button again to turn it off.
- **Remote mode** – In this mode, the beacon can be used as a remote control.

The Infrared Sensor will only detect a beacon on the channel specified in the software. If two robots are remote controlled by two different infrared beacons, they should use different channels, otherwise one beacon will control all of the robots on its channel

Figure 3.12; Infrared Beacon on Channel 1

MAKING SOUNDS

Sounds can be used to give a bot more personality. Using the Sound Block, it is possible to give your robot many things to say. These sounds can be used to mean different things; progress, dead end, crying, success and many more. Lots of sound files have been saved for used in the Sound Block.

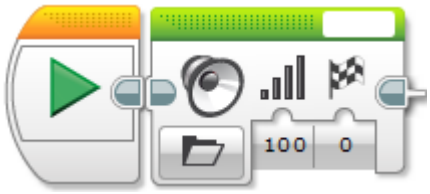

Figure 3.13; Sound Block

The section of the Sound Block above enclosed in a red box is where all the sound files are saved. Different files could be selected from there. This block has 4 modes from which you can choose how you would like your bot to speak.

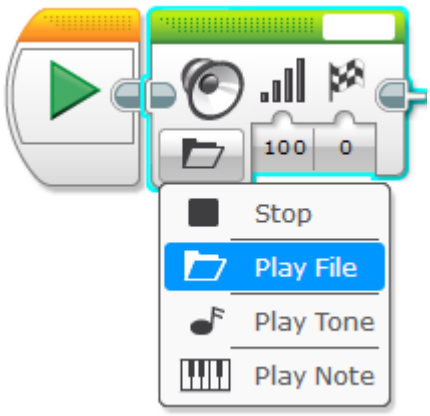

Figure 3.14; Sound Block mode

CHAPTER PROJECT: Detecting distance.

The project for this chapter is to program a robot that can detect the distance between it and objects before it. This can be done using the Infrared Sensor which can be used to detect distance.

First, you will need to have a robot before you can programme it. So build a robot you would like to program, then follow the steps below to program it.

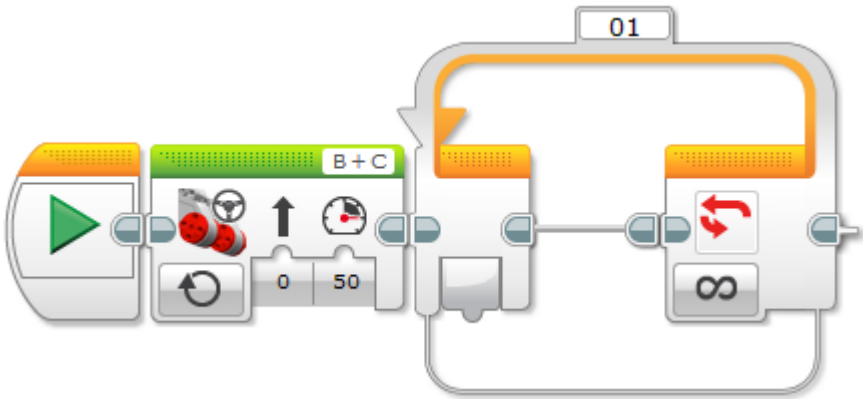

Figure 3.15; Programming a robot

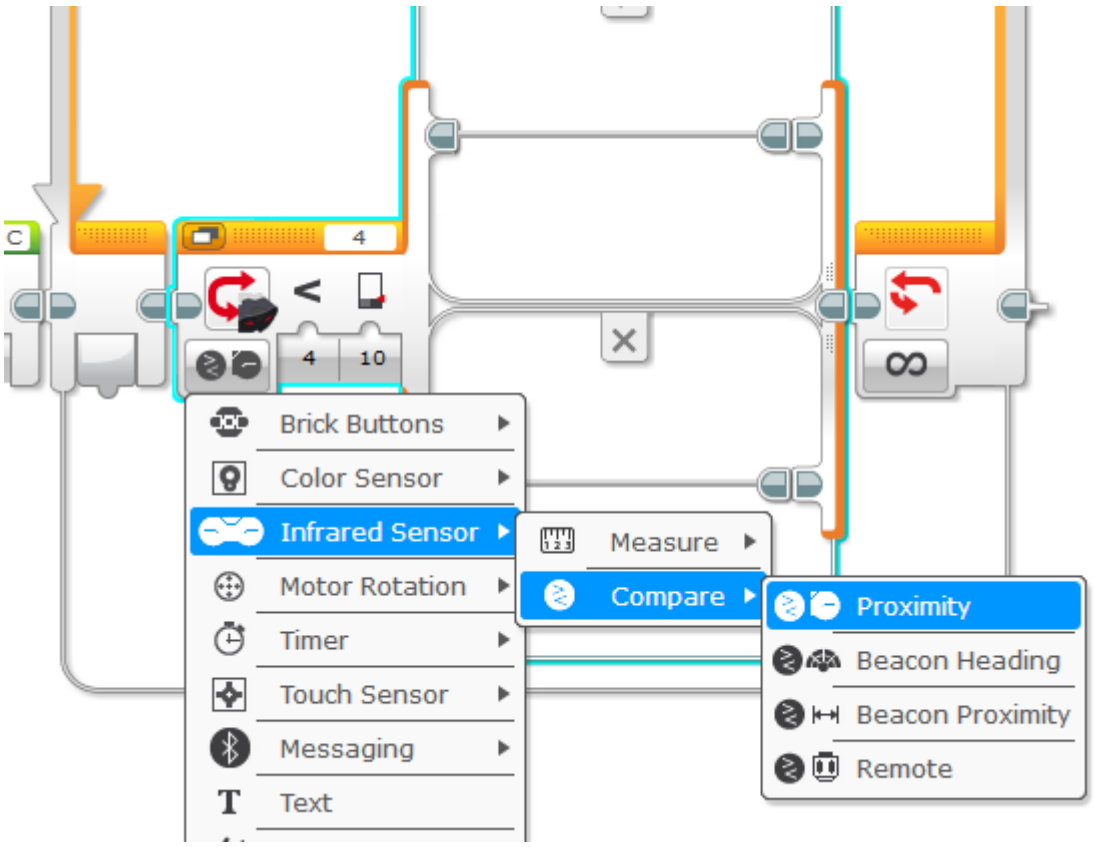

Figure 3.16; Programming a robot

Place a Switch Block inside the Loop Block and configure the mode as shown in the image above.

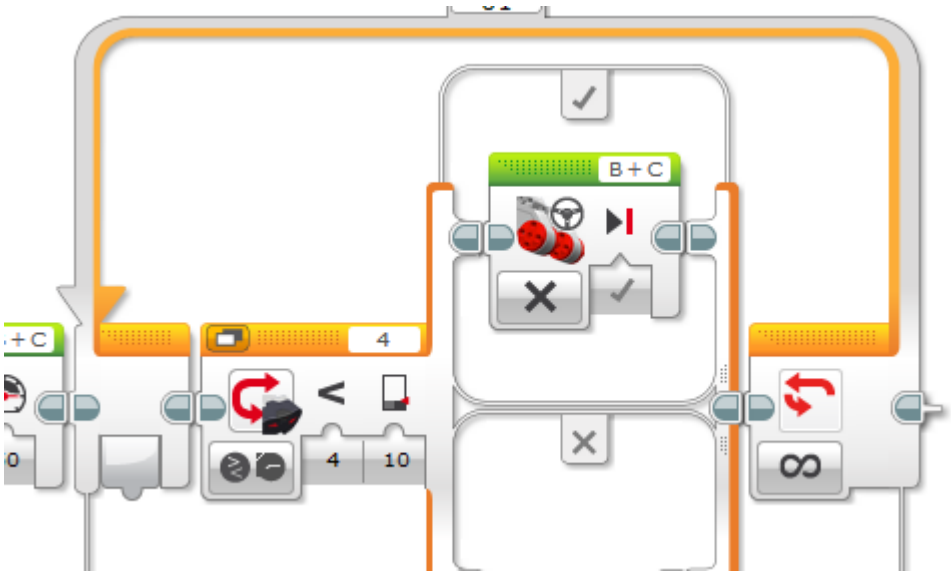

Figure 3.17; Programming a robot

Place a Steering Block inside the True container of the Switch Block and configure it as shown. Then place a Switch Block inside the False container of the Switch Block. See image below.

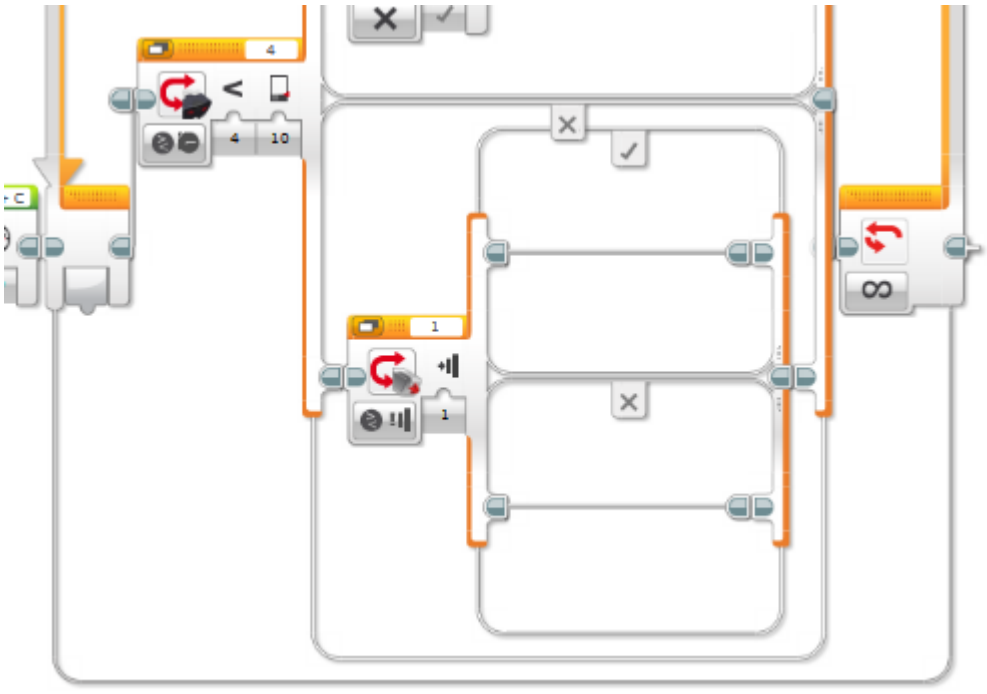

Figure 3.18; Programming a robot

Drag and drop a Steering Block in both the True and False container of the Switch Block and configure them as shown in the image below.

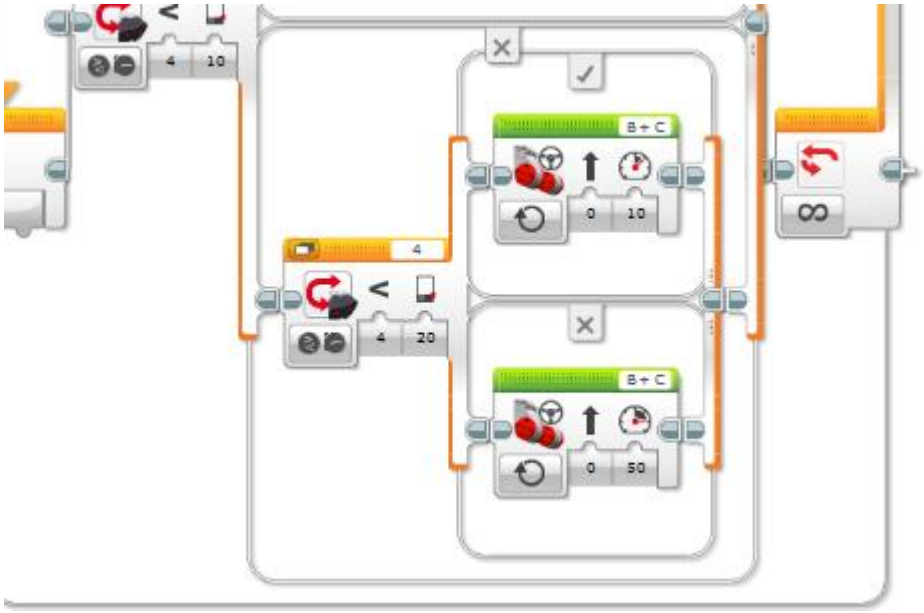

Figure 3.19; Programming a robot

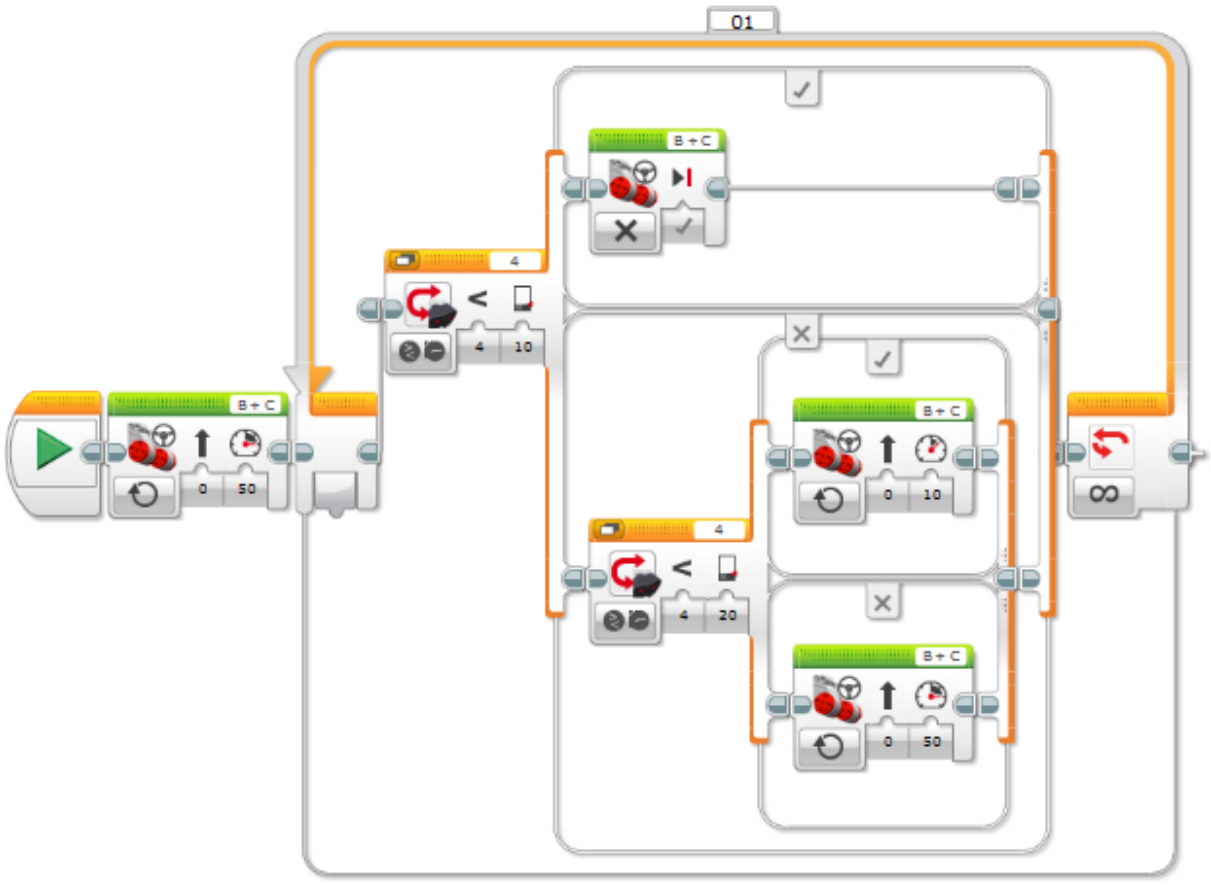

Figure 3.20; Programming a robot

Congratulations on the completion of this chapter.

SUMMARY

In this chapter, the students have learnt what sensors are. They now understand the importance of using sensors with respect to programming a robot. They can now explain the different types of sensors there are in the Lego Mindstorms EV3.

The students can now build a robot of their choice and attach a couple of sensor to it. They can also program the sensors to work appropriately.

CHAPTER 4

DATA OPERATIONS

Table of Contents

Learning Objectives

In this chapter, the students would:

- Understand how to use the Data Operations blocks
- Understand how to use the IR Sensor and Beacon to control a robot.

DATA OPERATIONS GUIDE BLOCKS

The Data Operations Blocks in the Palette are used to perform operations using data that have been inputted or gotten from the sensors and they send this data as output to execute other actions.

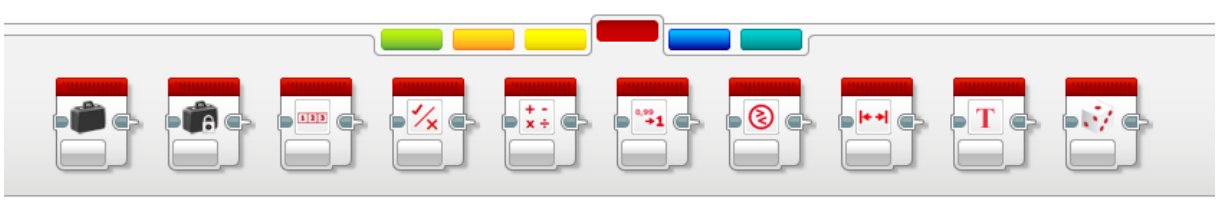

Figure 4.0; Data Operations Block palette

(In order from left to right)

- Variable
- Constant
- Array Operations
- Logic Operations
- Math
- Round
- Compare
- Range
- Text
- Random

Each block in the Data Operations Block has its function.

Math Block: This block performs arithmetic calculations on its inputs, and outputs the result.

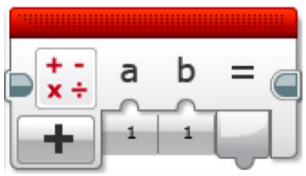

Figure 4.1; Math Block

Compare Block: This block compares two input values to see if they are equal or not.

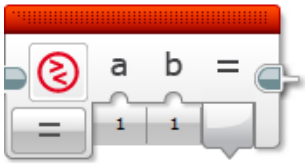

Figure 4.2; Compare Block

Round Block: This is used to round up or down a decimal number to the nearest whole number.

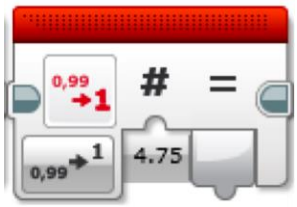

Figure 4.3; Round Block

Range Block: This block is used to test if an input value is within a specified numerical range or not.

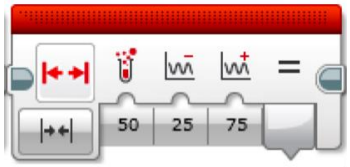

Figure 4.4; Range Block

Random Block: This is used to output a random numerical value

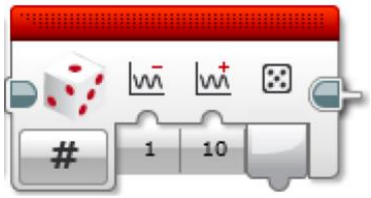

Figure 4.5; Random Block

Logic Operations: This block takes True / False inputs and produces a True / False output.

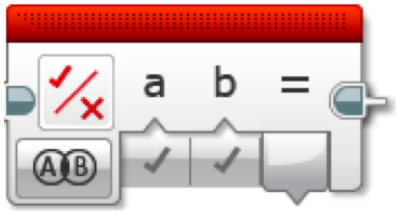

Figure 4.6; Logic Operations Block

REMOTE CONTROLLING

Here is an interesting part of building a robot. Imagine having to stand up and walk to where your TV is to change the channel. Imagine air conditioners have no remote to control. Then you would have to walk to its position to control it. Imagine the controls of Play Station 4 being on the console. Playing video games would be less fun.

Let's look at Remote Controlling in the perspective of a King and his servant. A king would not want to stress himself in getting up from his seat to change the channel or control the air conditioner. He would rather send his servant. A Remote Controller is a technological device that is used to operate another device wirelessly from a distance. So, rather than get up to change the channel of your TV, you can use its remote control from a distance. Technology makes life easier. Wouldn't you agree?

In remote controlling, two devices are needed;

- Sensor : This receives signals from the beacon.
- Beacon : This send signals to the sensor.

The kind of signals sent from the beacon is called **Infrared Waves.** This kind of wave cannot be seen with the naked eye. To be convinced that your remote control sends this infrared wave, place a mobile phone camera in front of the pointer of the beacon. You would see a purple light as your press the buttons on your remote. This indicates that infrared waves are being sent from the beacon to the sensor.

CHAPTER PROJECT: Remote controlling a GRIPP3R.

Controlling a robot with a remote is always a fun thing to do. So in this chapter's project, we will be programming the GRIPP3R to respond to the IR Beacon which will be used as a remote controller.

Let us have some fun.

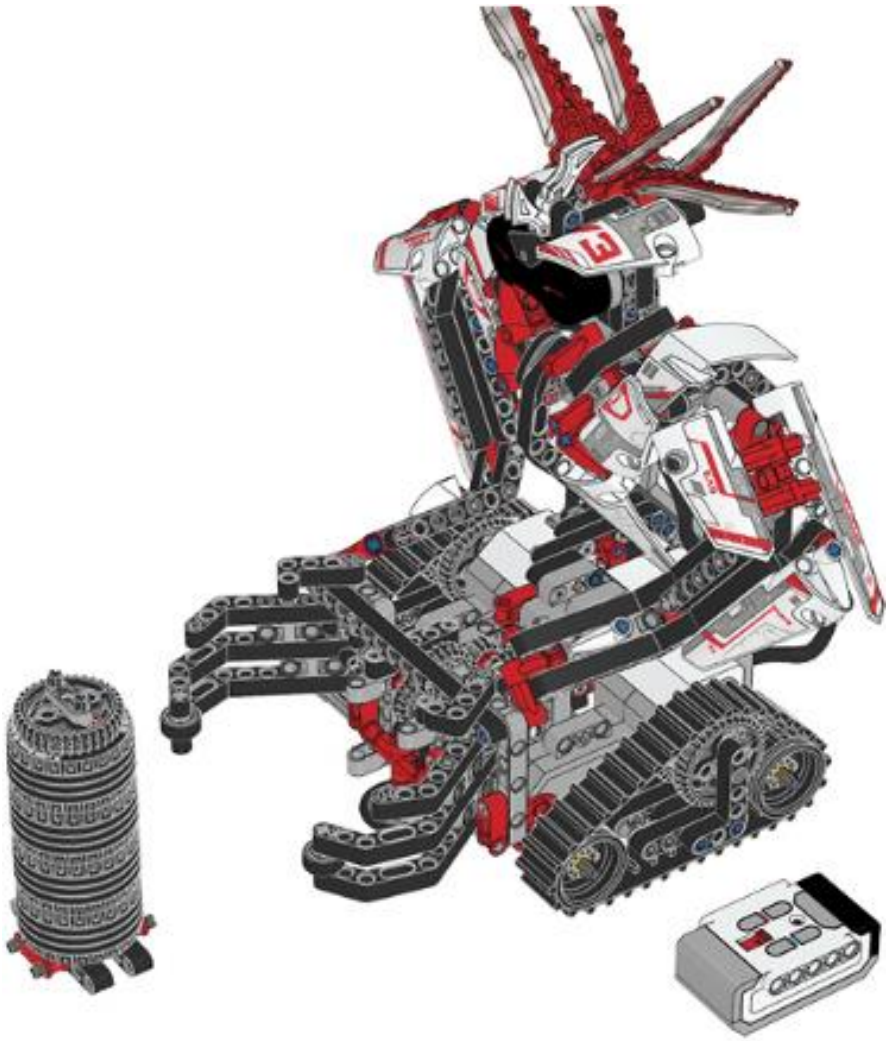

Figure 4.7; A GRIPP3R

Navigate to the Programming interface of the Lego Mindstorms EV3 software. Having done that, follow these steps sequentially.

This is what you should have on the canvas of your software.

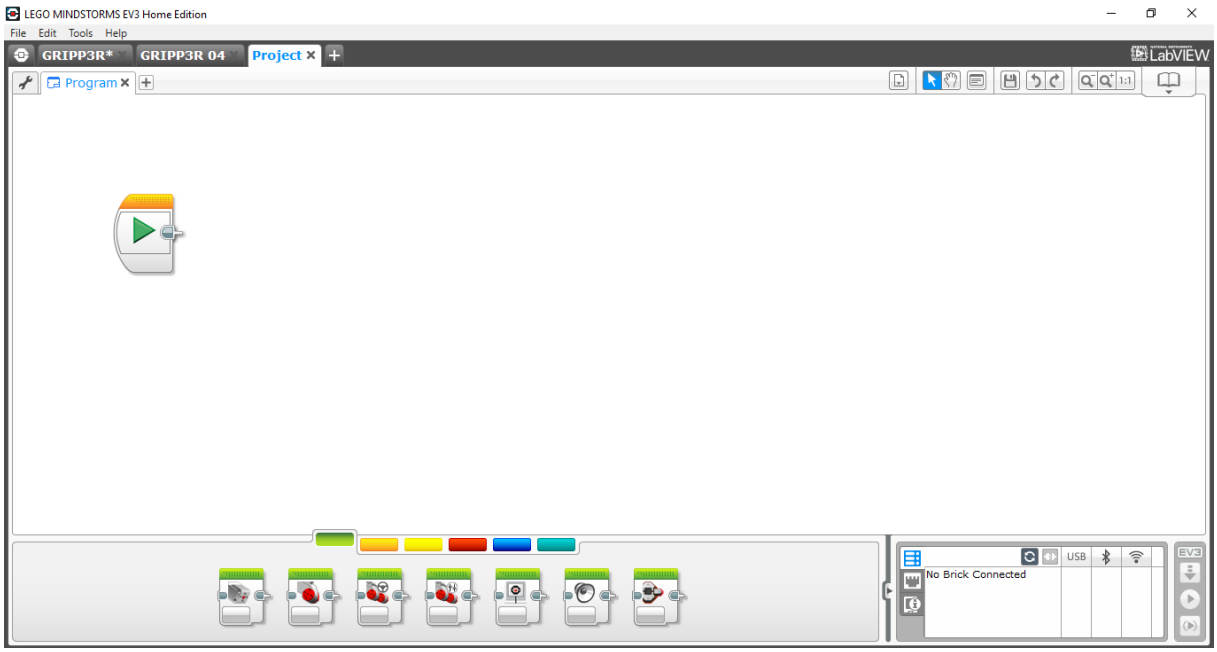

Figure 4.8; Programming a robot

Place a Loop Block after the Start Block

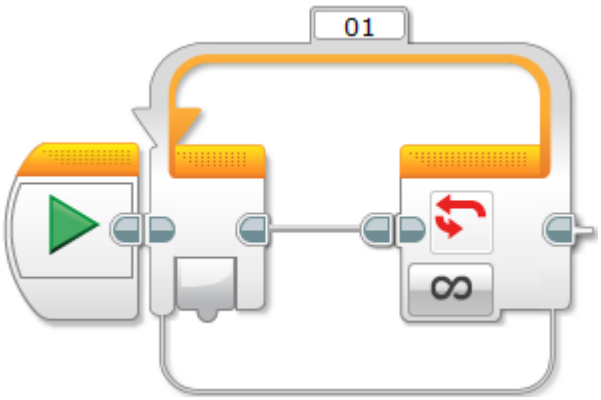

Figure 4.9; Programming a robot

Place a Switch Block inside the Loop Block. Change the mode to Infrared Sensor -> Compare -> Remote. Check options 1,5,6 and uncheck all other options.

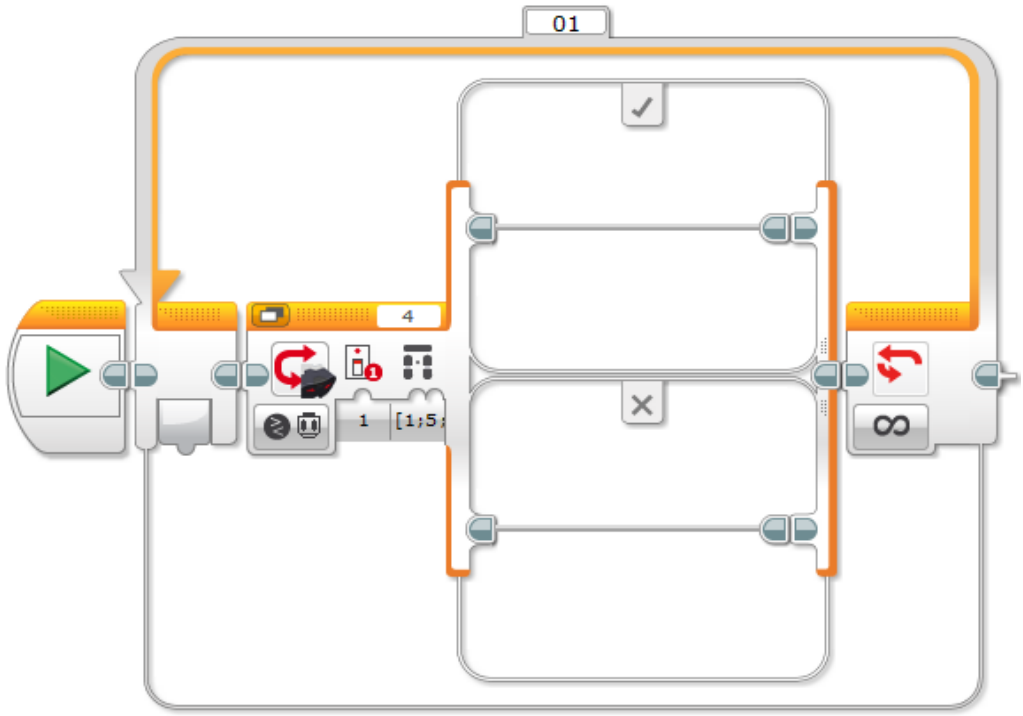

Figure 4.10; Programming a robot

Place a Large Motor Block inside the True Case (Upper Case) of the Switch Block. Change the mode to on and make sure the port is set to B.

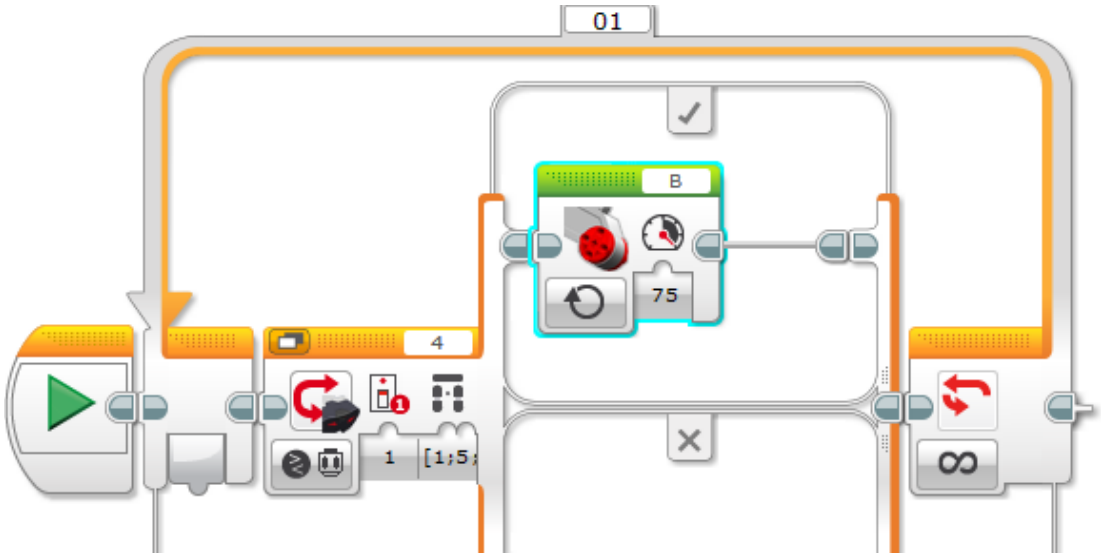

Figure 4.11; Programming a robot

Place a Switch Block inside the False Case (Lower Case) of the Switch Block. Change the mode to Infrared Sensor -> Compare -> Remote. Check options 2,7,8 and uncheck all other options.

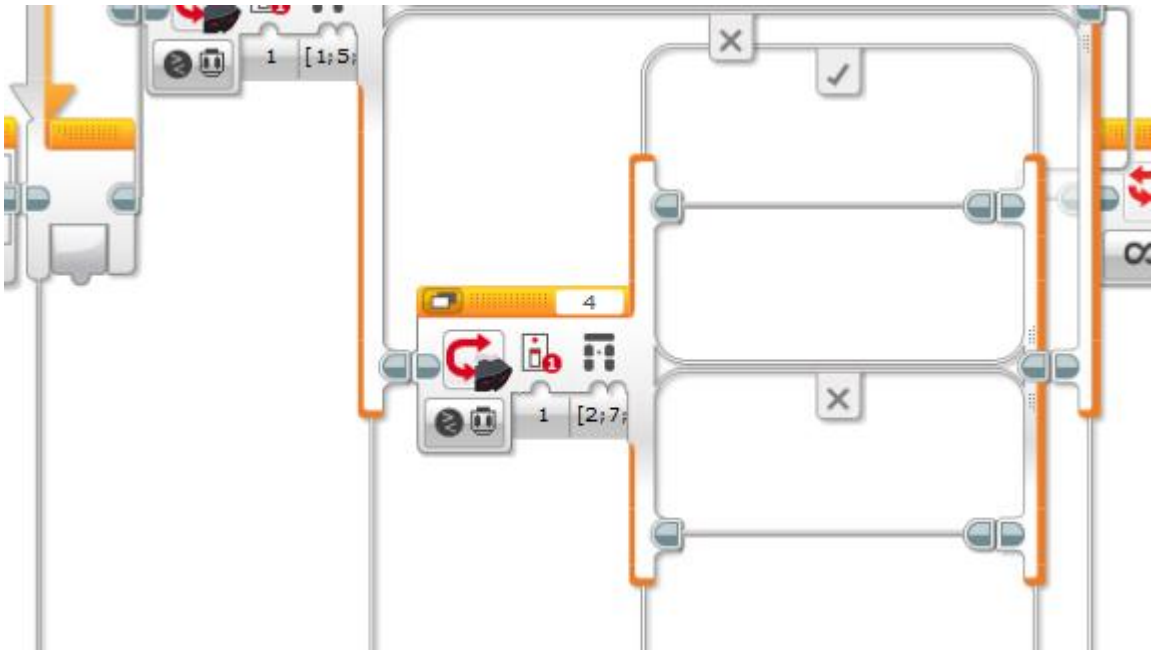

Figure 4.12; Programming a robot

Place a Large Motor Block inside the True Case (Upper Case) of the Switch Block. Change the mode to on and make sure the port is set to B. Change the power to -75.

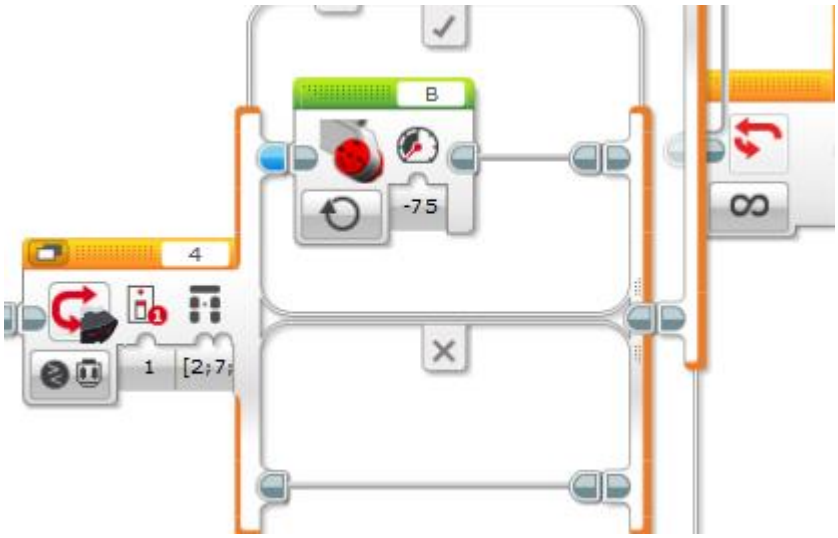

Figure 4.13; Programming a robot

Place a Large Motor Block inside the False Case (Lower Case) of the Switch Block. Change the mode to off and make sure the port is set to B. Set Brake at end to **X** Coast.

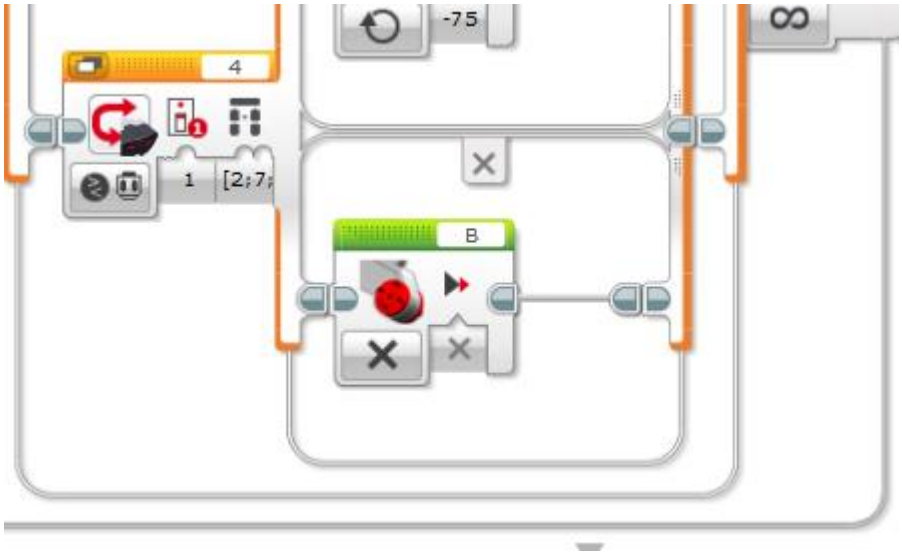

Figure 4.14; Programming a robot

Place a Switch Block after the Switch Block. Change the mode to Infrared Sensor -> Compare -> Remote. Check options 3,5,7 and uncheck all other options.

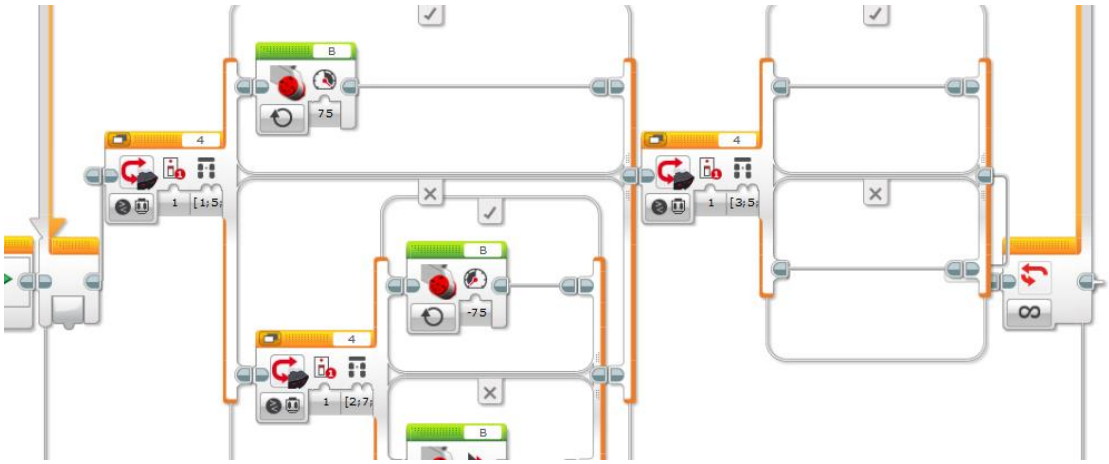

Figure 4.15; Programming a robot

Place a Large Motor Block inside the True Case (Upper Case) of the Switch Block. Change the mode to on and make sure the port is set to C.

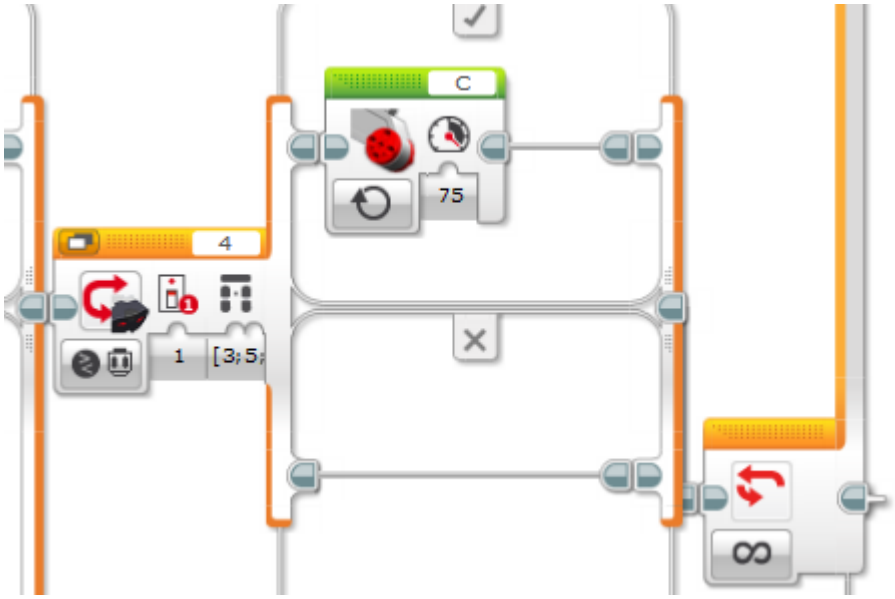

Figure 4.16; Programming a robot

Place a Switch Block inside the False Case (Lower Case) of the Switch Block. Change the mode to Infrared Sensor -> Compare -> Remote. Check options 4,6,8 and uncheck all other options.

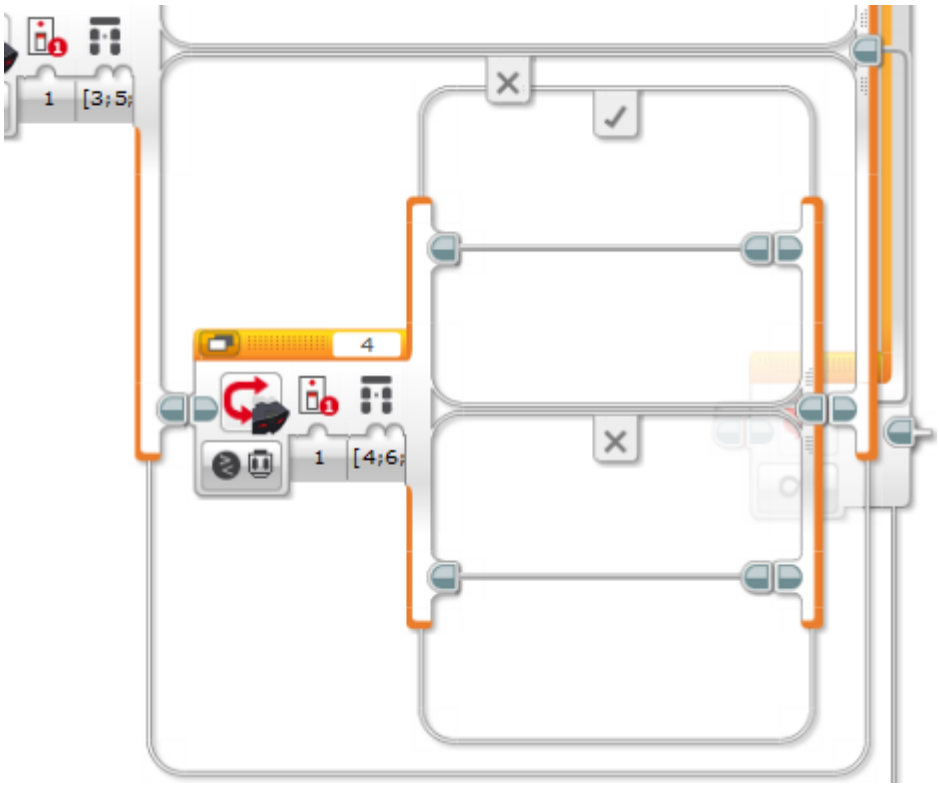

Figure 4.17; Programming a robot

Place a Large Motor Block inside the True Case (Upper Case) of the Switch Block. Change the mode to on and make sure the port is set to C. Change the power to -75.

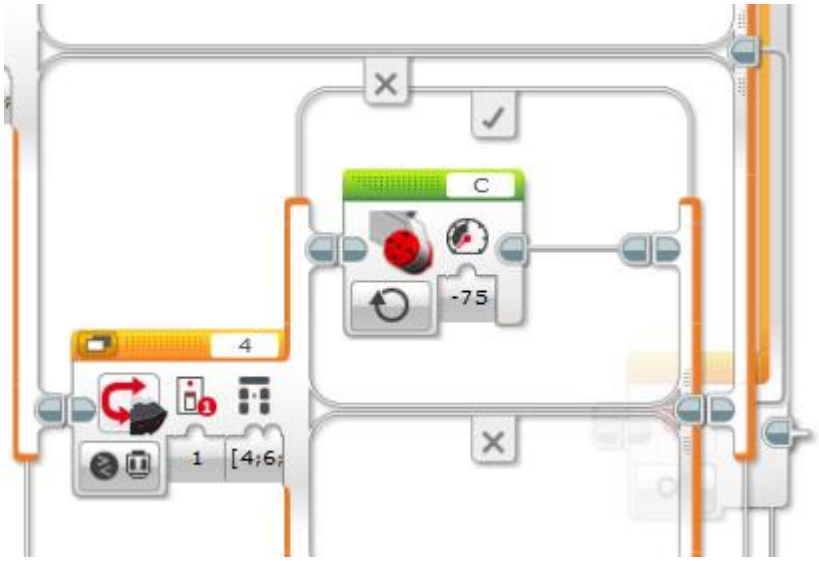

Figure 4.18; Programming a robot

Place a Large Motor Block inside the False Case (Lower Case) of the Switch Block. Change the mode to off and make sure the port is set to C. Set Brake at end to **X** Coast.

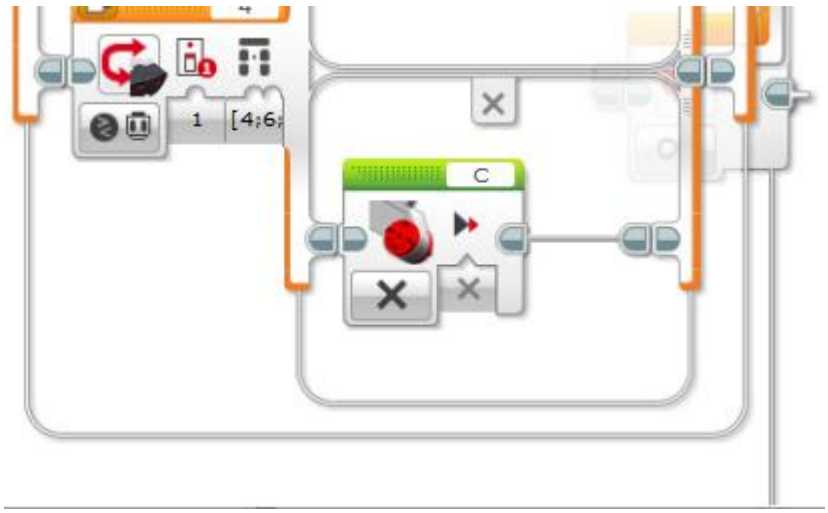

Figure 4.19; Programming a robot

Place a Switch Block after the Switch Block. Change the mode to Infrared Sensor -> Compare -> Remote. Check option 9 and uncheck all other options.

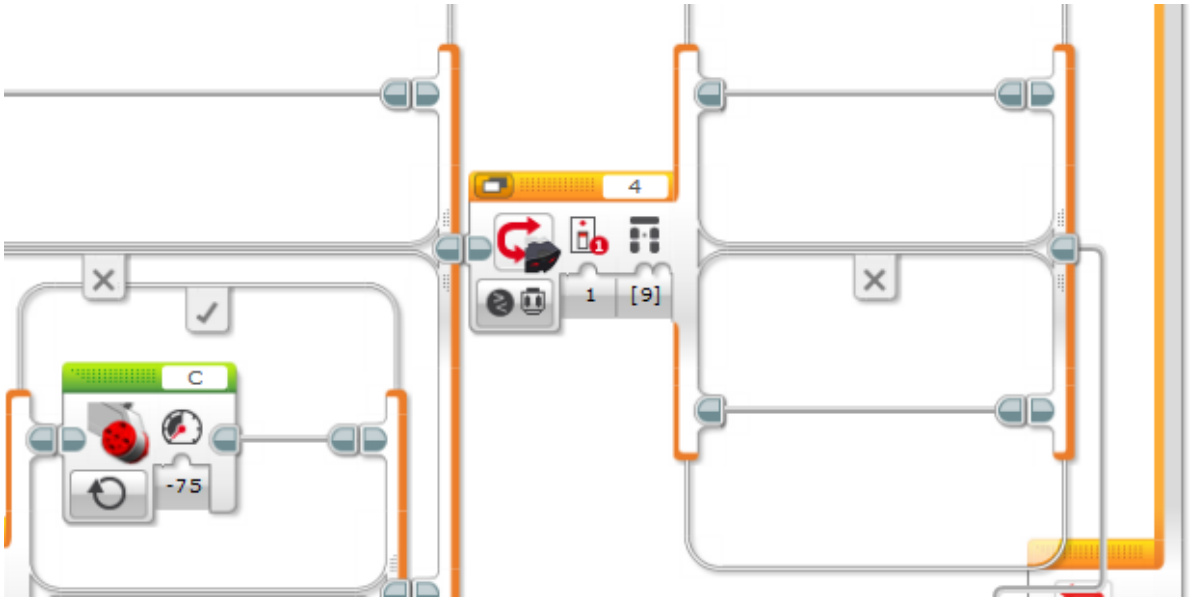

Figure 4.20; Programming a robot

Place a Switch Block inside the True Case of the Switch Block.

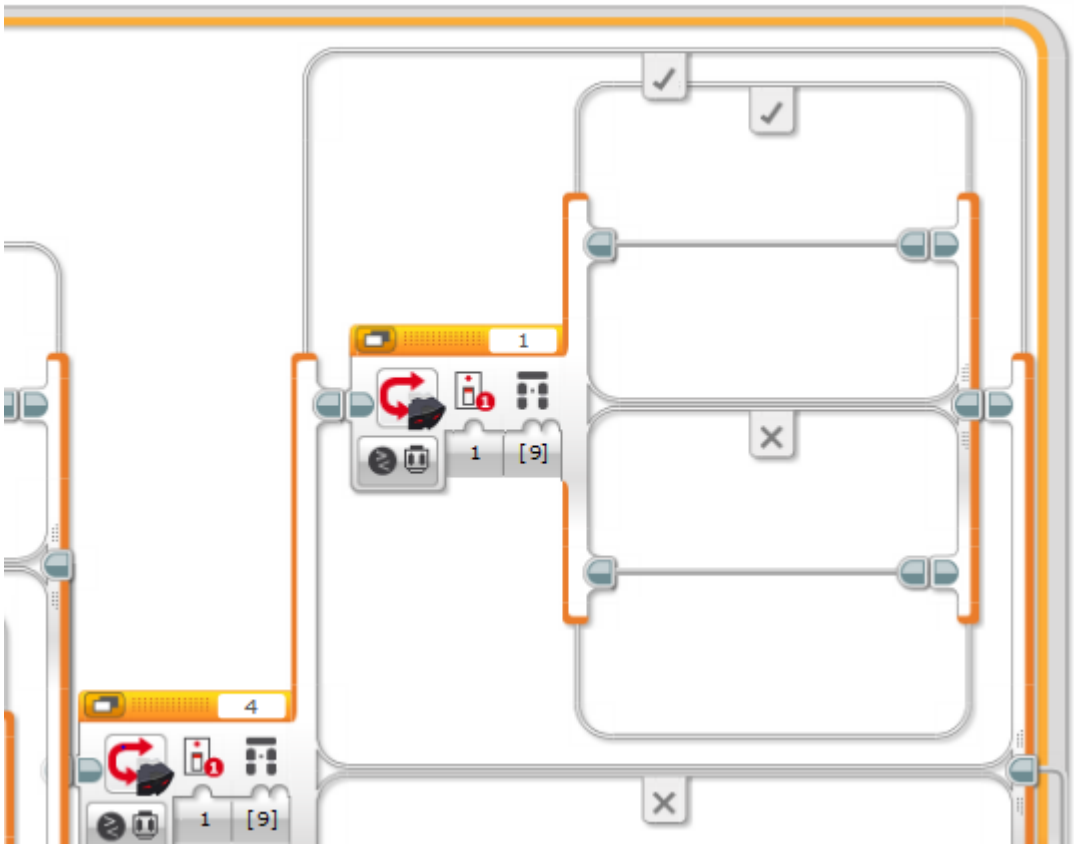

Figure 4.21; Programming a robot

Place a Medium Motor Block inside the True Case of the Switch Case. Change the mode to on for seconds.

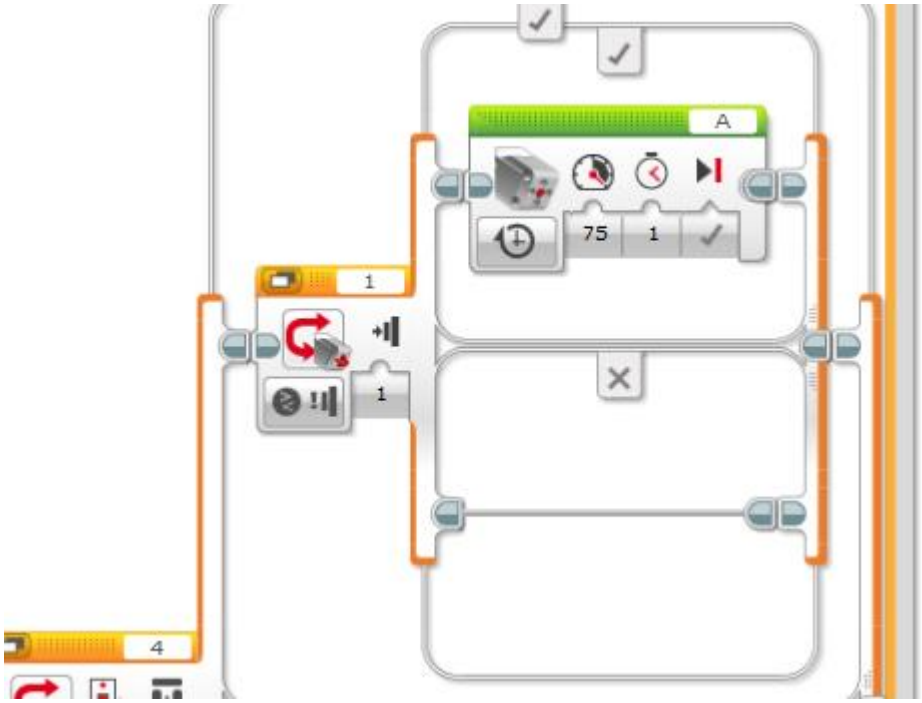

Figure 4.22; Programming a robot

Place a Medium Motor Block inside the False Case of the Switch Block. Change the mode to on for seconds. Change the Power to -75.

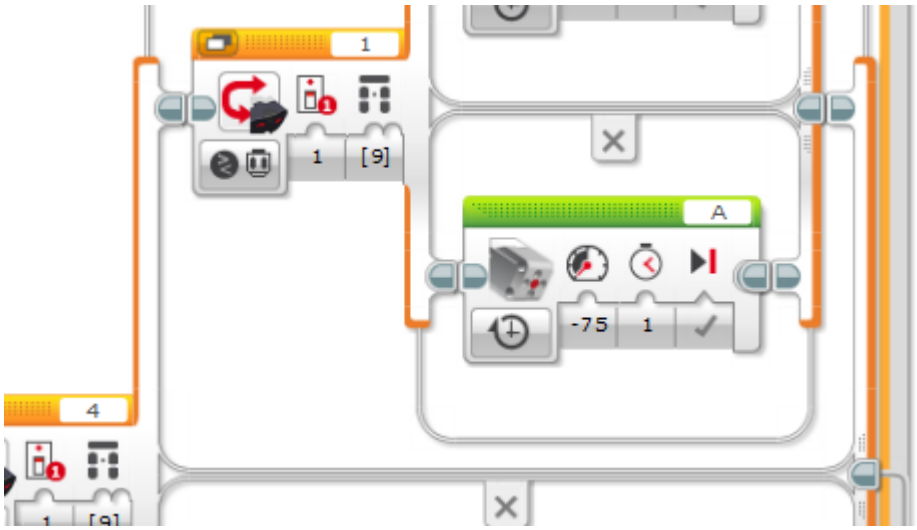

Figure 4.23; Programming a robot

Place a Medium Motor Block inside the False Case of the Switch Case. Change the mode to off.

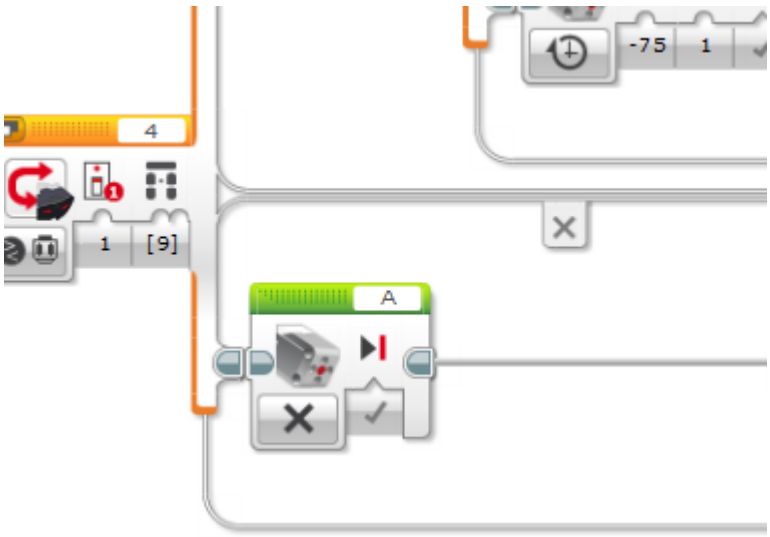

Figure 4.24; Programming a robot

Place a Wait Block after the switch Block. Change the mode to Infrared Sensor -> Change -> Remote.

You are now ready to try out your robot. Congratulations. Here is the Programming Overview of your programme.

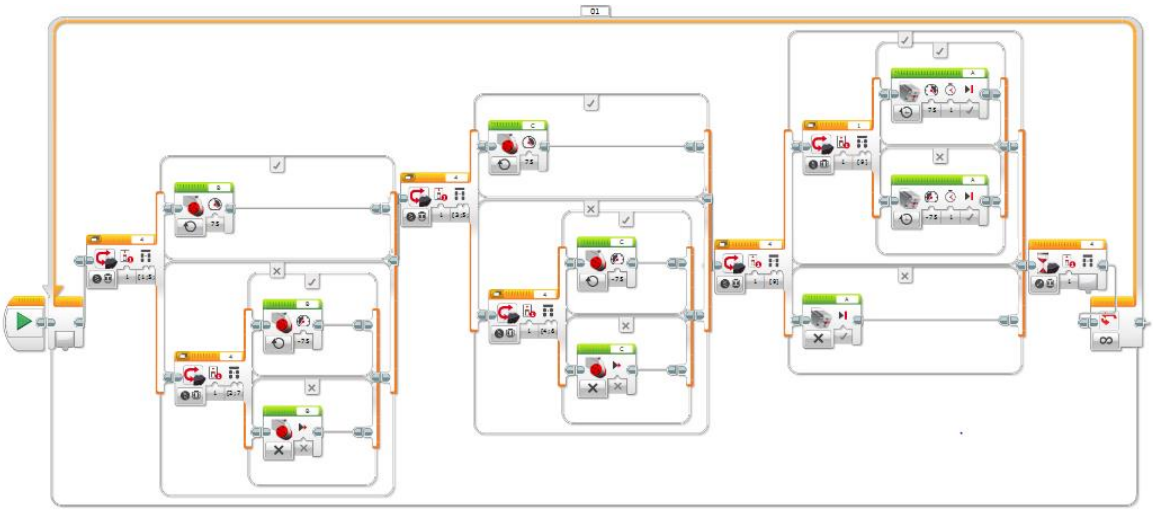

Figure 4.25; Programming a robot

Connect your EV3 Brick to your computer and download the Programme.

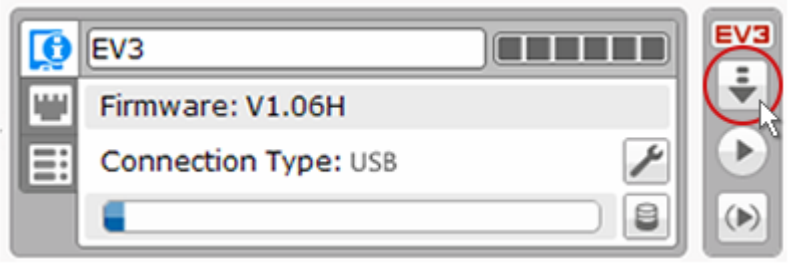

Figure 4.26; Downloading the program

Place the GRIPP3R and the stack of tires on a smooth surface and Run the Programme.

Use the Infrared Beacon on Channel 1 to control GRIPP3R (the Beacon Mode Buttons controls the Grasping GRIPP3R).

SUMMARY

In this chapter, the students have learnt about the Data Operations Blocks of the Lego Mindstorms EV3. They now know how to use the block effectively when programming a robot.

The students have learnt how to program a robot to be controlled with the Infrared Beacon as a remote controller. They understand it fully and can modify the program till their desire is met.

CHAPTER FIVE

ADVANCE PROGRAMMING GUIDE

Table of Contents

- Advanced Blocks
- Communicating

Learning Objectives:

By the end of this chapter, the students would understand how to use the Advanced Programming Blocks to:

- Send messages to other EV3 Bricks.
- Make bluetooth connections using the Bricks.
- Make robots communicate.
- Place comments in their programmes.

.**Chapter Prerequisites**

_____- A Completely built Lego Mindstorm EV3 Robot

- A laptop or desktop computer with the EV3 software installed on it.

ADVANCED BLOCKS

The Advance Blocks can be found in the Palette of the Lego EV3 programming screen interface. They are in blue colour and just as the name implies, they are used to give your robots some advanced programming. The image below shows the Advance Block in the palette.

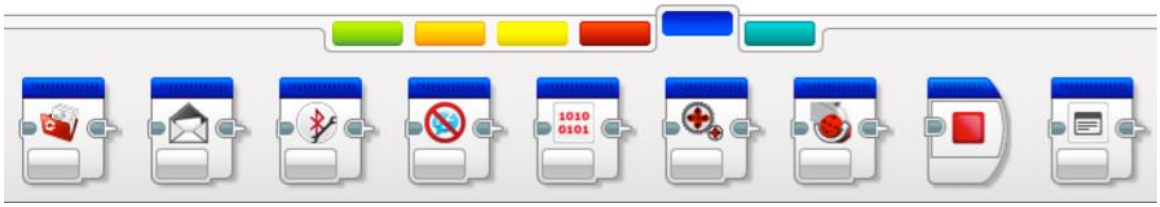

Figure 5.0; Advanced Block Palette

Advanced Blocks

(from left to right)

- File Access Block
- Messaging Block
- Bluetooth Connection Block
- Keep Awake Block
- Raw Sensor Value Block
- Unregulated Motor Block
- Invert Motor Block
- Stop Program Block
- Comment Block

File Access Block: This block allows you to make files with texts or numbers on them. It has four modes;

- Read
- Write
- Delete
- Close

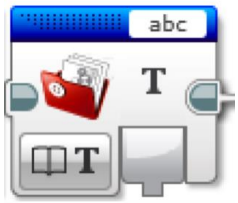

Figure 5.1; File Access Block

Messaging Block: This block allows you to send or receive messages from other Bricks. It can also be used to compare messages received. This can be done by using a Bluetooth Connection Block.

Figure 5.2; Messaging Block

Bluetooth Connection Block: This block is used to initiate a connection, join a connection or clear a connection to another Brick.

Figure 5.3; Bluetooth Connection Block

Keep Awake Block: As the name implies, this block prevents the Brick from falling asleep.

Figure 5.4; Keep Awake Block

Raw Sensor Value Block: This block allows the robot use the actual value which the sensor reads. That is, it does not allow the Brick turn the values into a more useable value.

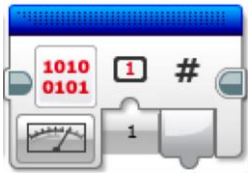

Figure 5.5; Raw Sensor Value Block

Unregulated Motor Block: This block does the same function as the Move Block except that it does it at a slower speed.

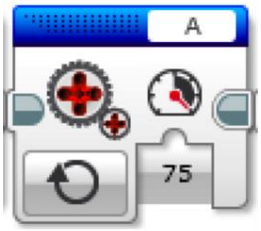

Figure 5.5; Unregulated Motor Block

Invert Motor Block: This block is used to make the motor turn in the opposite direction. For instance, if the motor is turning clockwise, this block can be used to make it go counter clockwise.

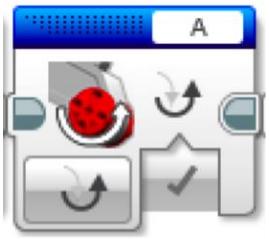

Figure 5.6; Invert Motor Block

Stop Program Block: This block brings an end to your program immediately. This block can be very useful when running multiple sequences and you want both to stop one after the other.

Figure 5.7; Stop Program Block

Comment Block: This block is used to write comments in your program. It could be used to help remember the steps used in coding your robot. It does not add anything to the code.

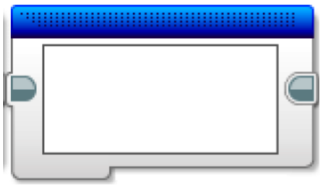

Figure 5.8; Comment Block

COMMUNICATING

Imagine a situation where there is a student who just got admitted into a new school. This means he or she will have a new classroom, a new class teacher, new classmates, new friends, new environment and so on. For most students, the first day would be very boring. This is because there would not be much communication between that particular student and other students. One good way to make being in the school for that student is through interaction with other students. This is done through communication. Therefore, communication is very paramount. It gives living more meaning.

Now imagine making a robot you have built communicate with another built robot. This would make building a robot more fun as it would make the robot look alive. With a few simple steps in using the Messaging Block of the Lego Mindstorms EV3, we would make two robots communicate with one another.

Let us begin.

First, you have to understand that communication between two robots can only be made possible when the communicating robots are paired in a bluetooth connection. So the first thing to do is to pair the two robot's Brick. For this project example, i will be naming my robots Blue and Yellow.

Step 1: Navigate to bluetooth in the settings menu in the EV3 block. Select Connections and then select the name of the robot to be paired with. If the robot name is not visible, select <Search>. *See images below.*

Figure 5.9; Pairing two bricks

Figure 5.10; Pairing two bricks

Figure 5.11; Pairing two bricks

Step 2: The robots need to know their name. So at this step, you name your robots. Connect your robot to your computer. On the Hardware Page of the Programming Interface, make sure the 'i' icon is selected in the lower right hand box. Than enter the name of your robot in the text box. Do the same thing for both robots. *See image below.*

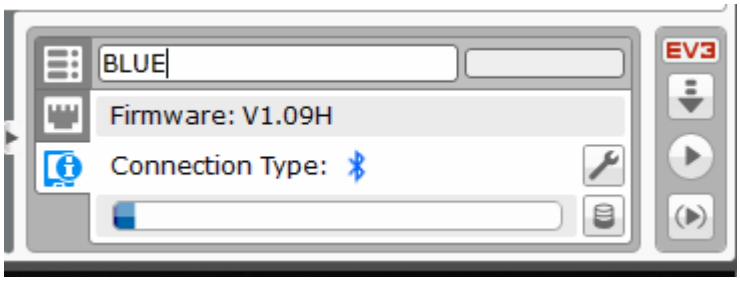

Figure 5.12; Naming your robots.

Step 3: Initiate the communication

Next, the robots need to know how to communicate with each other, which requires Bluetooth connection. Drag and drop your blocks as shown in the images below and type in the name of the robot that your robot will send messages to. (Make sure the Brick's Bluetooth is turned on.) In this case, Blue is sending to Yellow.

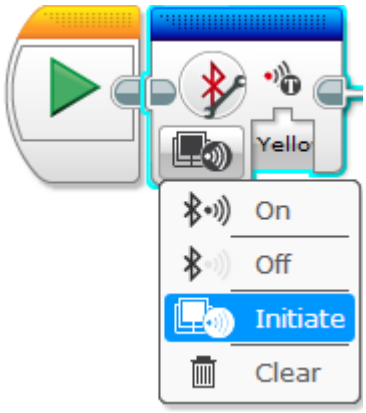

Figure 5.13 ; Initiating Bluetooth Connection

Next, add a Wait Block from the Flow Control Blocks to make the robot wait for a command. Arrange and configure your blocks as shown in the images below. This configuration will make the robot (Blue) wait until the middle button of the Brick is pressed before sending a message to Yellow.

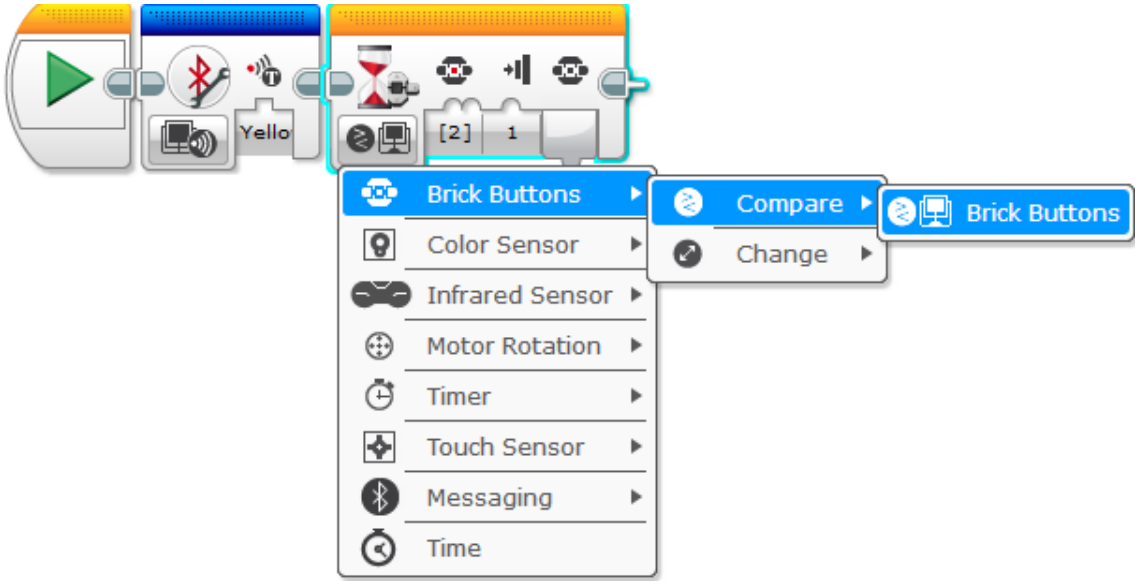

Figure 5.14 ; Configuring the Wait Block

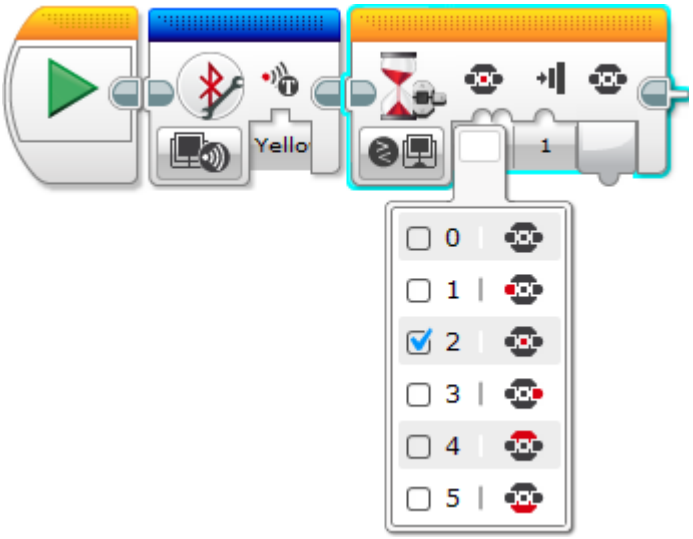

Figure 5.15 ; Configuring the Wait Block

Finally, add a Messaging Block. Type in the name of the robot you are sending a message to and type in the message 'Race?'.

.

Figure 5.16 ; Code for Blue sending a message to Yellow

Now that we have programmed Blue to send a message to Yellow. Let us program Yellow to receive the message. Add the following codes shown in the image below. (This program is for Yellow alone.)

Figure 5.17 ; Code for Yellow responding to the message from Blue

Figure 5.18 ; Using the Comment Block

Step 4: Add some codes. Now that Blue has sent a message to Yellow about having a race, it is time to add a code for both robots on how you would want them to race. So add some codes now to make your robot race on a suitable track. From the knowledge you have gotten from the previous chapters, you could as well add programs to make the robots respond to the Infrared Beacon which could be used as a remote control for your bots. This would make the race fun.

What are you waiting for? Have some fun.

CHAPTER PROJECT: Pick a partner to build the same kind of robot with. Program both robots to communicate and do whatever the communication is about. You could make your robots race or dance. Just remember to be creative.

SUMMARY

In the just concluded chapter, you were introduced to the Advanced Blocks in the Lego Mindstorms EV3 programming block palette. You have learnt about the importance of each of the blocks. That is, you now understand how to use the Advanced Blocks in programming your robot.

You were introduced to the communication that can exist between two robots. This is done using the Advanced blocks which you now know. You now have the knowledge of how to make two robots communicate with one another.

CHAPTER SIX

CREATING BLOCKS

Table of Contents

Learning Objectives:

In this chapter, the students will;

- Be introduced into My Block palette.
- Understand how to create their own EV3 blocks.
- Understand how to export and import their EV3 blocks.

.**Chapter Prerequisites**

_____- A Completely built Lego Mindstorm EV3 Robot

- A laptop or desktop computer with the EV3 software installed on it.

INTRODUCTION TO MY BLOCKS

Figure 6.0; My Blocks Palette

You probably must have come across the empty My Block Palette in the Lego Mindstorms EV3 Software. The option was left by LEGO for you to create your own block from any of the existing blocks. That is, you can pack several existing blocks which you make use of frequently into one new block. You could do this so as to save yourself more time from having to bring out each block to configure them. For instance, if you use the Medium Motor and Steering Motor together a lot, you could create your own block and combine the Medium Motor and Steering Motor Blocks into your own created block. In that way, you can easily reuse parts of your programs throughout your project and even in other projects.

CREATING MY BLOCKS

Creating your own blocks in the Lego EV3 Software can be done easily by following the few steps shown below.

The first thing to do is to arrange all the blocks according to how you want them to work. Then highlight all of the blocks. Do NOT highlight the Start Block else you get an error message.

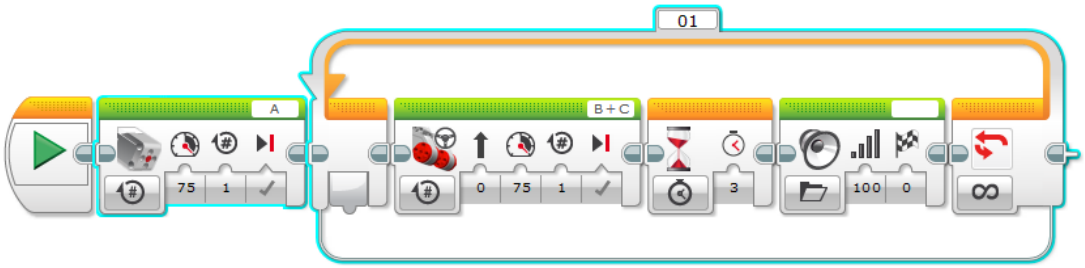

Figure 6.1; Creating your own EV3 block

Then select “Tools > My Block Builder”. A new window will pop up.

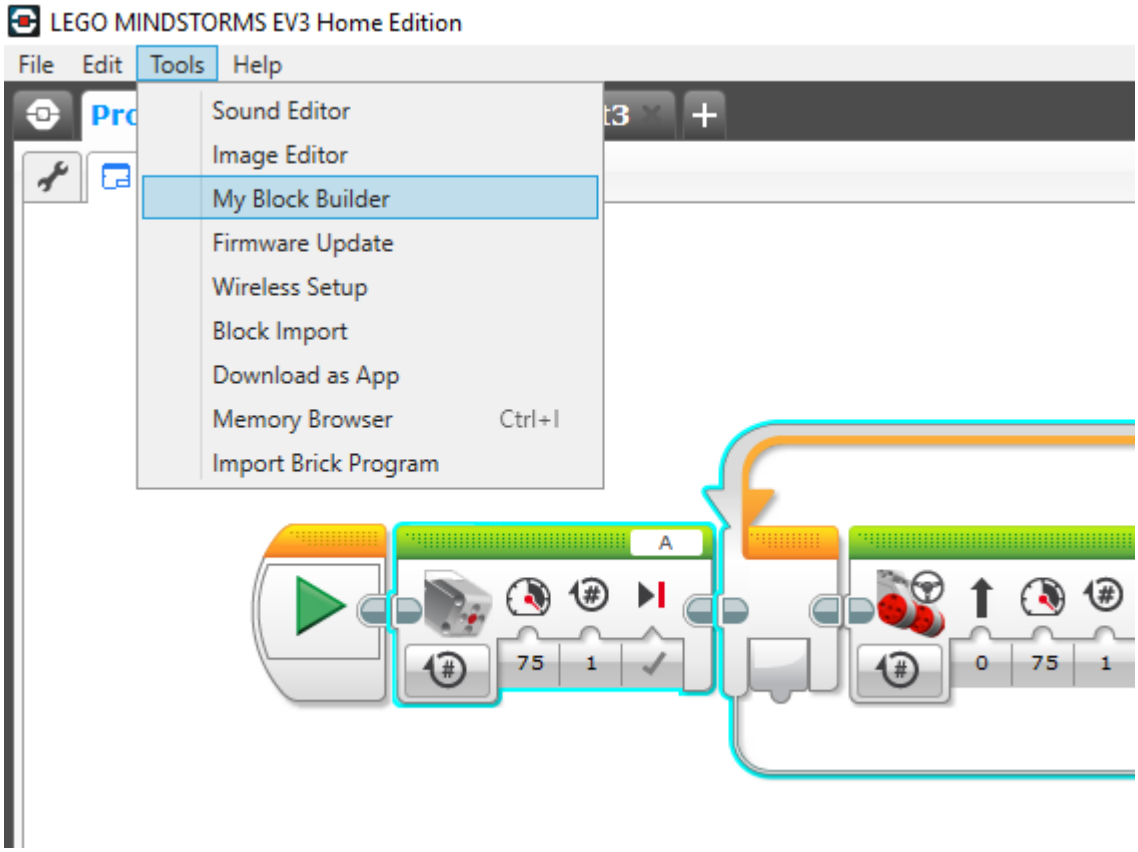

Figure 6.2; Creating your own EV3 block

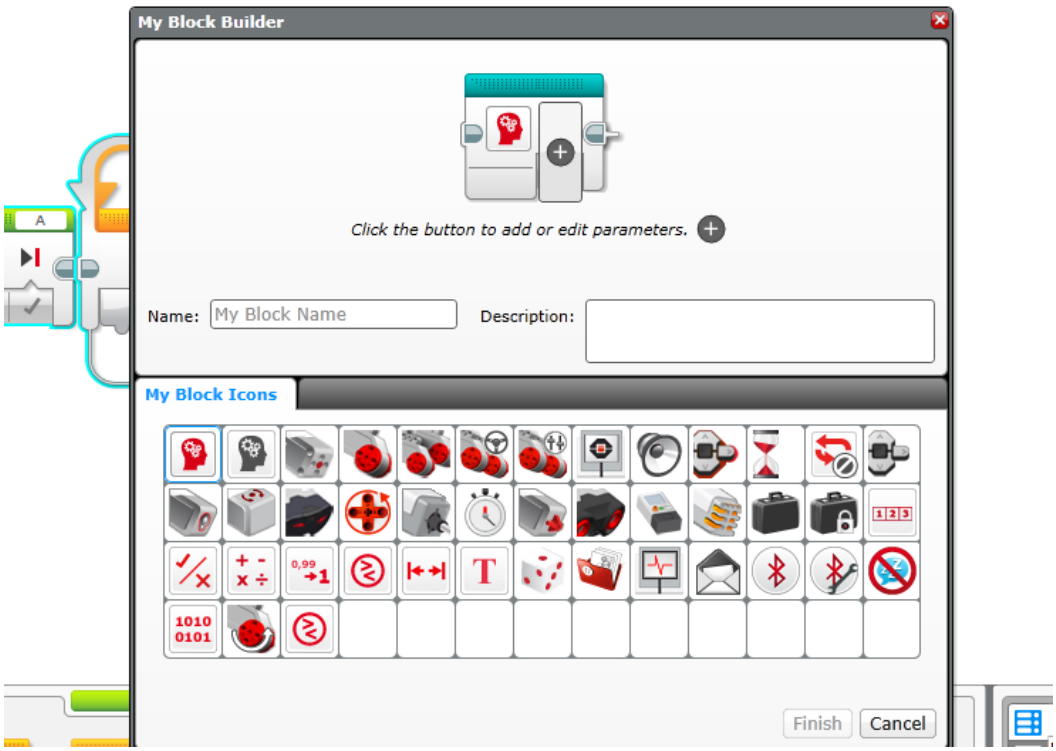

Figure 6.3; Creating your own EV3 block

From this window, you will set all the settings of the new block you are creating. Settings such as name, description, icon and parameters. The name and description used should be something meaningful that tells what the purpose of the block is.

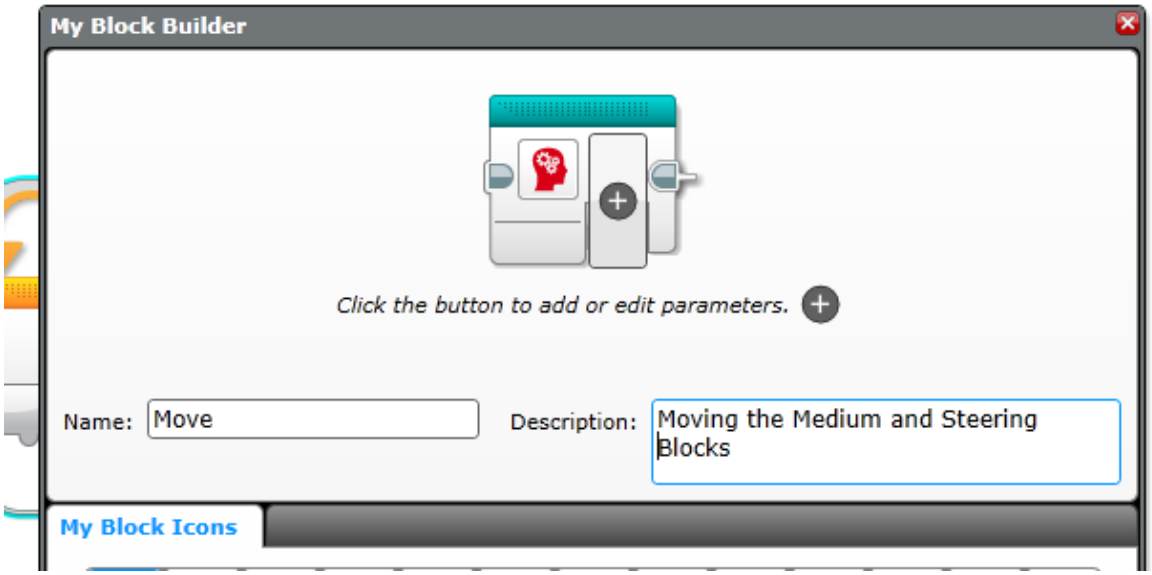

Figure 6.4; Creating your own EV3 block

Finally, select the icon for the new block. This is probably the most important part of creating a new block because it will be the main way to distinguish blocks in the palette. Once you have chosen an appropriate icon, select **Finish.**

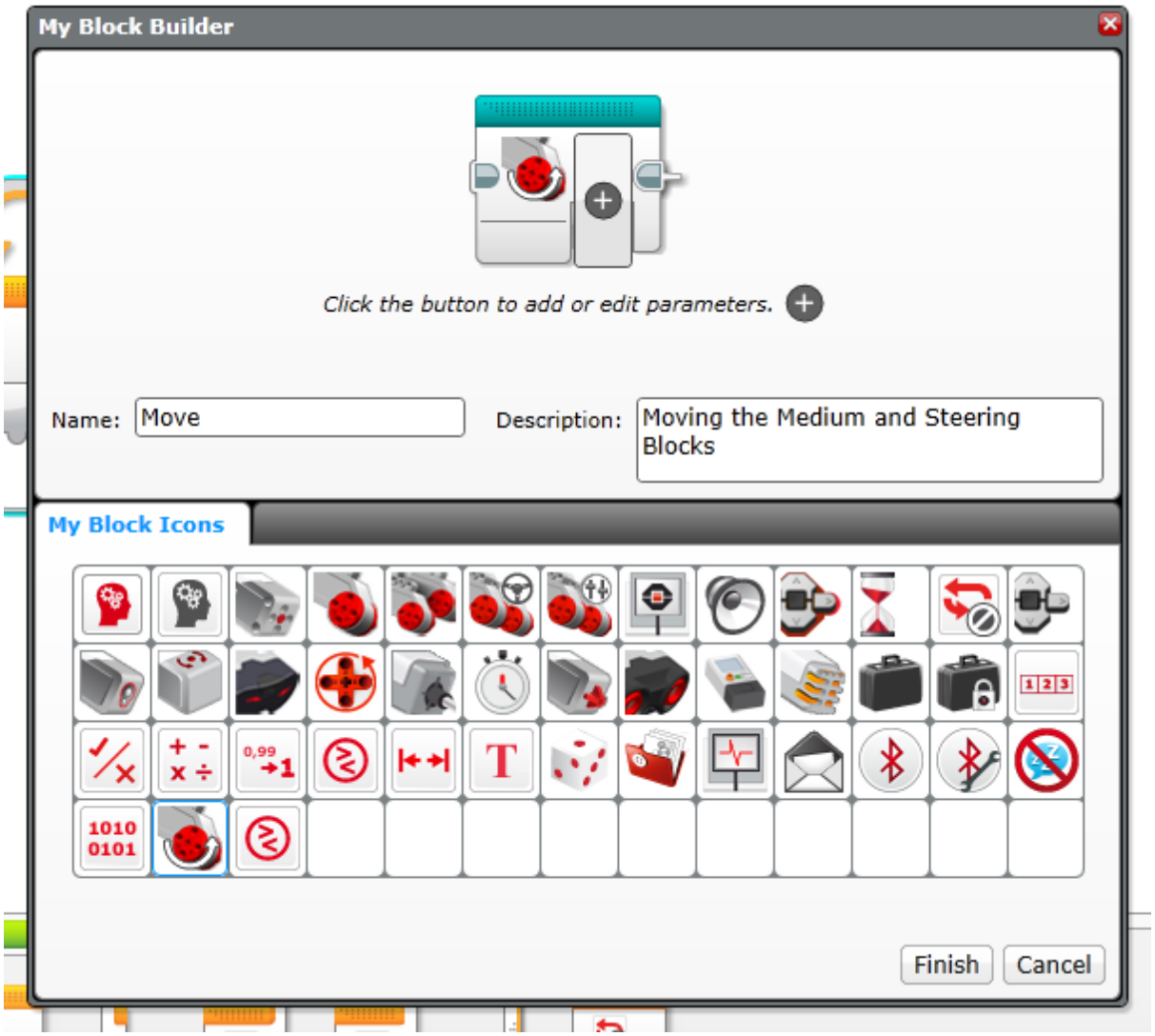

Figure 6.5; Creating your own EV3 block

Once the Finish button has been clicked, all the highlighted blocks will be combined into your newly created block. The block will be available for selection in the My Block palette.

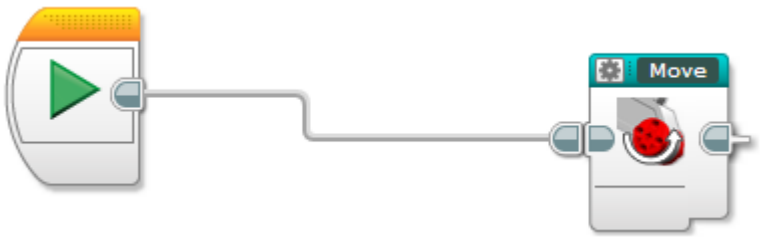

Figure 6.6; Creating your own EV3 block

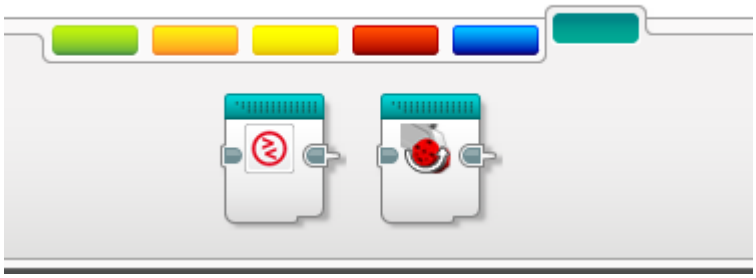

Figure 6.7; Creating your own EV3 block

Congratulations on creating your own Lego Mindstorms EV3 Block.

IMPORTING AND EXPORTING EV3 BLOCKS

It should be understood that blocks which you create yourself will only be available in the project in which it was created. The newly created block will not be available in the My Block palette to be used in other projects. This is not to say it cannot be used in other projects. For you to be able to use a block you have previously created in a new project, you will need to export it and save it in a folder that will not be forgotten. This way, the block can be imported whenever you would like to use it in a new project. Exporting and importing a block is easy. Follow the steps below to know how.

First, you will need to export the block. Click on the Project Properties icon which can be found at the top right corner of the programming screen.

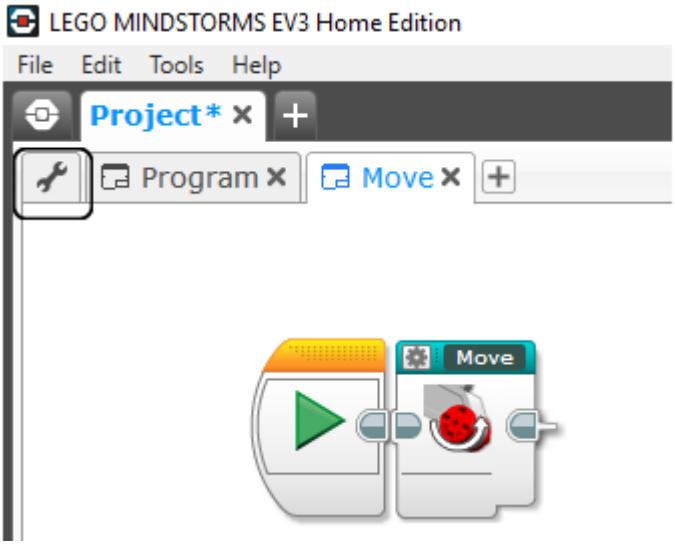

Figure 6.8; Exporting and Importing an EV3 block

Once clicked, a screen like the one below should appear.

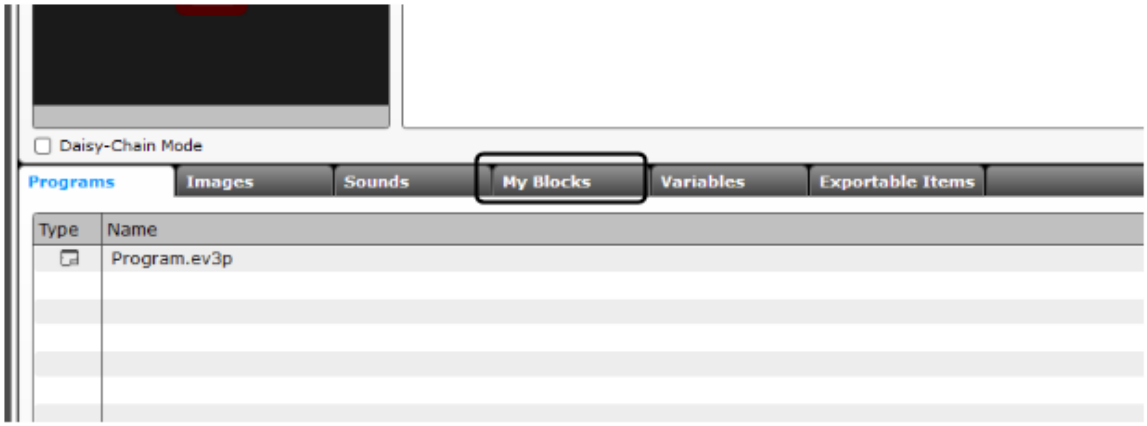

Figure 6.9; Exporting and Importing an EV3 block

Click on My Blocks to see all the blocks which you have created on that particular project.

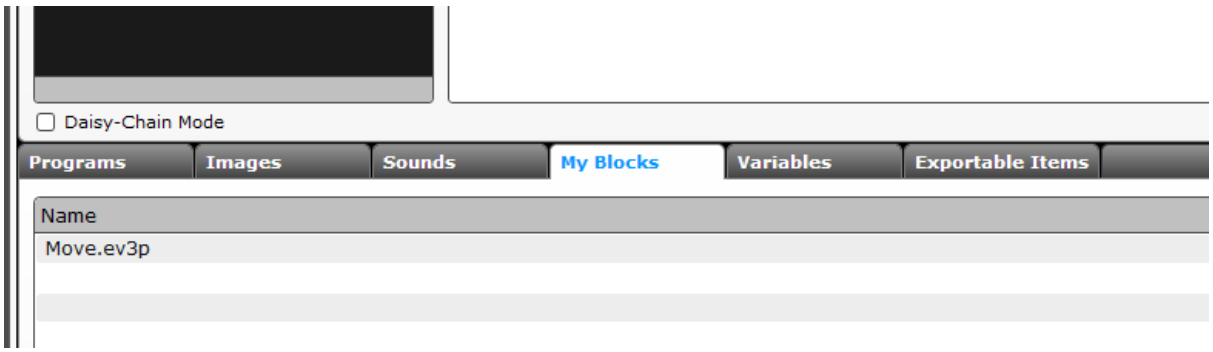

Figure 6.10; Exporting and Importing an EV3 block

Click on the block you would like to export and click on Export.

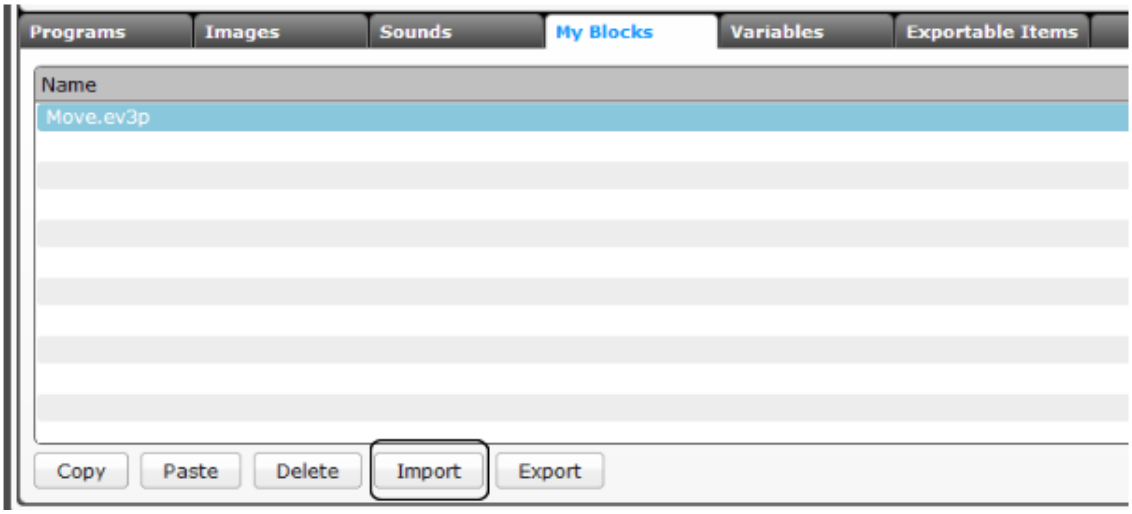

Figure 6.11; Exporting and Importing an EV3 block

A new window will pop up for you to save your block on your computer. You could create a folder for saving all your created blocks. Input the name of the block and click on save.

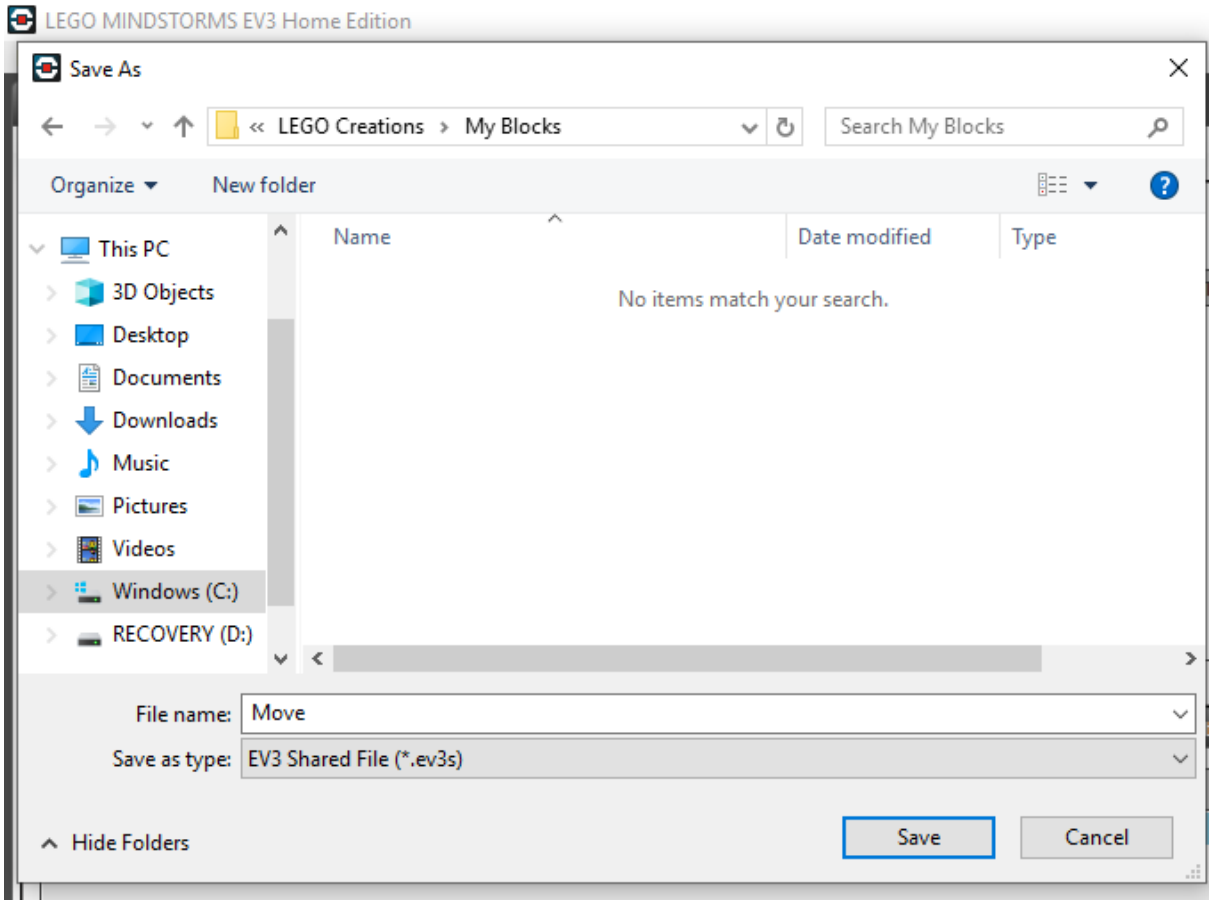

Figure 6.12; Exporting and Importing an EV3 block

Once Save is clicked, the block will be exported to your computer and it can be imported anytime as long as the file is not deleted from the computer. Follow the steps below to learn how to import blocks which have been saved.

When on the new project you will like to use your exported block on, navigate to the Project Properties and click on Import.

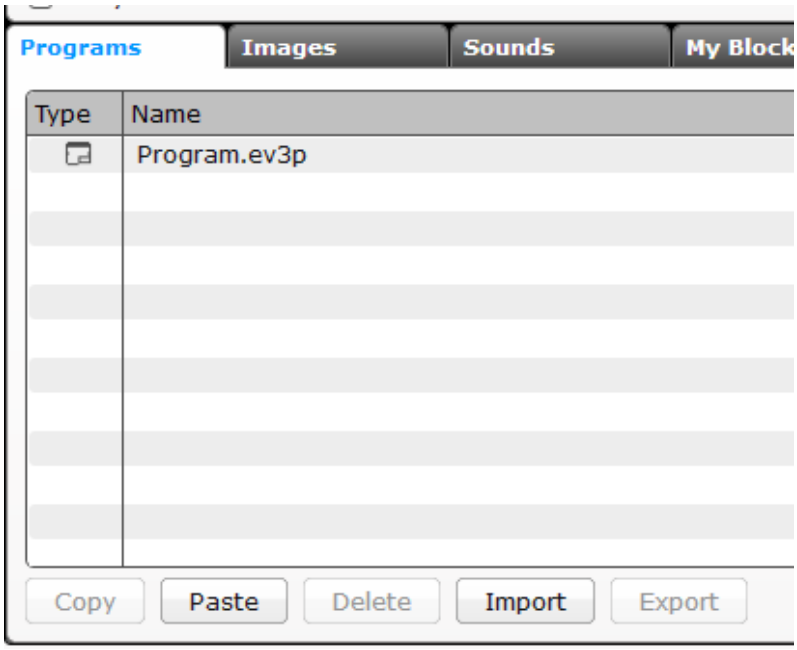

Figure 6.13; Exporting and Importing an EV3 block

A window will open where you will see the block(s) which you have previously created and exported. Click on the block or type in the name of the block you would like to import. Then click on Open.

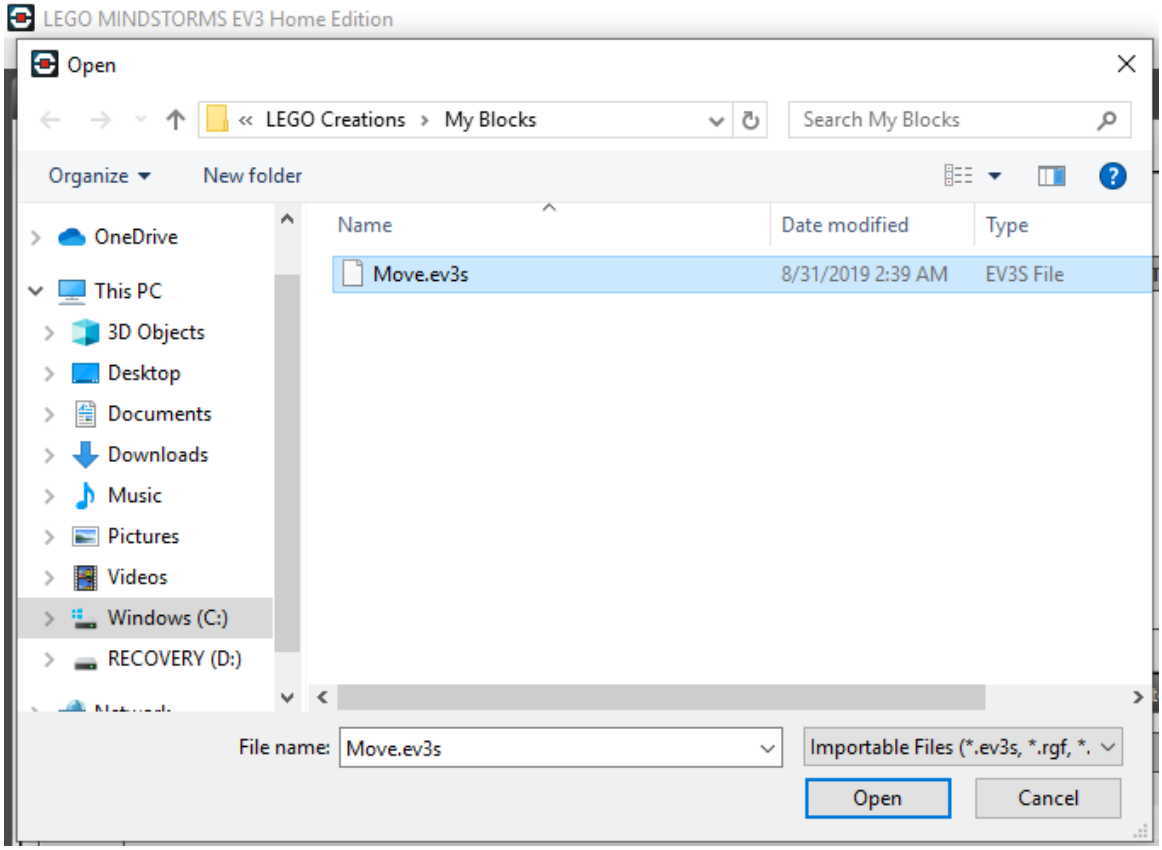

Figure 6.14; Exporting and Importing an EV3 block

The block which you created and exported will now be available for any project you would like to use it in. All that is needed to do is to import it anytime it is needed.

NOTE: The file (the created block) should not be deleted from your computer.

CHAPTER PROJECT: Build and program the all terrain EV3RSTORM robot.

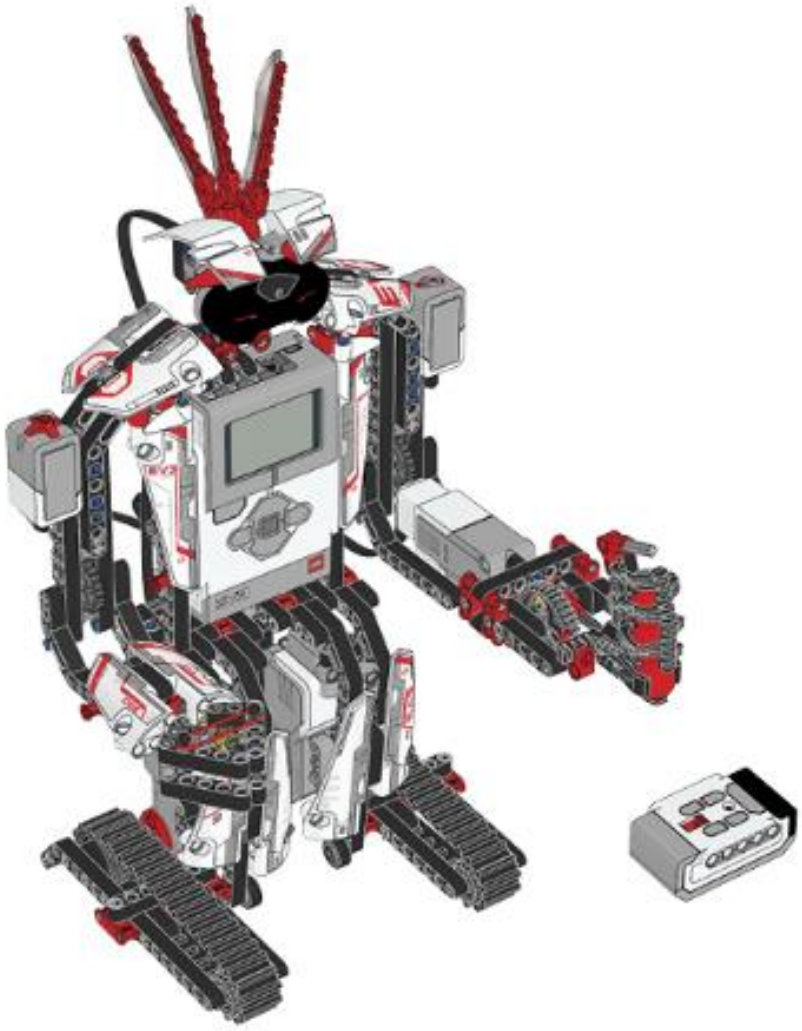

Figure 6.15; EV3RSTORM Robot

SUMMARY

In this chapter, you have been introduced into the My Block palette. You now know that new blocks can be created in Lego Mindstorms EV3 and you now understand how to create your own blocks from any of the existing blocks. You understand the importance of having to create your own blocks.

You were introduced into exporting and importing blocks from your computer to save time and stress.