Ev3 Robotics Programming 101
Self Introduction

- Name: Robert Jones
- Goes by: Mr. Jones, or Rob (your choice)
- Family: Father of two adult children
- Job: Product Development for Car Air Bag Computers
- Education: Electrical Engineering
- Lives: Detroit, MI near Cooke STEM Elementary
- Hobbies: Cooking, fixing up my old house, guitar, motorcycles
- Why am I here? Find and train our future engineers
- Favorite Quote: “The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man.” ~ George Bernard Shaw
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1. EV3 main components and use
2. Programming environment overview
3. Connecting your Robot wirelessly via bluetooth
4. Starting and understanding the EV3 programming environment
5. Writing your own program
   1. How to write a program
   2. Controlling motors and other outputs
   3. Your first program
   4. Reading sensors
   5. Loops
   6. Your second program
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- Angle (Gyro) Sensor
- Brick – The robot’s “brain”
- Medium Motor
- Touch sensor
- Large Motor
- Color Sensor
- Distance (Ultrasonic) sensor
- Lifter mechanism
- Cuboid
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Large Motor
- Lets you program precise and powerful robotic action.

Medium Motor
- Maintains precision, while trading some power for compact size and faster response.

EV3 Brick
- Serves as the control centre and power station for your robot.

Ultrasonic Sensor
- Uses reflected sound waves to measure distance between the sensor and any objects in its path.

Colour Sensor
- Recognizes seven different colours and measures light intensity.

Gyro Sensor
- Measures how fast and how far your robot is turning.

Rechargeable Battery
- Economical, environmentally friendly, and convenient power source for your robot.

Touch Sensor
- Recognizes three conditions—touched, bumped, and released.
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EV3 Control System

Inputs
- Ultrasonic
- Color
- Touch
- Gyro
- Sensors
- Time
- Brick Buttons

Control
- EV3 Program

Outputs
- Sound
- Motors
- EV3 Display
- Data Log
- Button Backlight
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Brick Features

A, B, C, D
Motor Output

1, 2, 3, 4
Sensor Inputs

PC Hardwire
USB
Connection

Bluetooth PC Connection

Display

Pushbuttons

Lego Connection Points
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Brick Display

Wireless Connection Status Icons
(from the left):
- Bluetooth enabled but not connected or visible to other Bluetooth devices
- Bluetooth enabled and visible to other Bluetooth devices
- Bluetooth enabled and your EV3 Brick is connected to another Bluetooth device
- Wi-Fi enabled but not connected to a network
- Wi-Fi enabled and connected to a network

USB
USB connection established to another device

Brick Name

POWER ON: 2

POWER OFF: 1,3,2 in order

Brick Buttons
1. Back
   This button is used to reverse actions, to abort a running program, and to shut down the EV3 Brick.

2. Center
   Pressing the Center button says “OK” to various questions—to shut down, to select desired settings, or to select blocks in the Brick Program App. You would, for example, press this button to select a checkbox.

3. Left, Right, Up, Down
   These four buttons are used to navigate through the contents of the EV3 Brick.
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Programming Environment - Lobby

Go to Project
* Means not saved

Options

Start a New Project
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Exercise 1 - Connecting Your Robot

1. Turn on robot and wait for green light

2. Enable bluetooth on EV3

3. Name your robot on EV3

4. Start up EV3 software on your computer. Click on the connect window

5. Connect robot through robot connection window and EV3
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Programming Environment – Programming Window

Main Menu

Program

Program Block Menu

Robot Interface
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Robot Connection Window – Connection View

Connection Type: USB, Bluetooth, Wifi

Robot Info
Port View
Connection View

Robot Name
Refresh
Connected

Disconnected

Connected
Download
Start/Stop
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Robot Connection Window – Connection View

Values can be reset or change options on what is displayed
Remember port letters and numbers for programming!
Robot Connection Window – Connection View

(Call up this window by selecting Tools=>Update Firmware)

Firmware Version Available

Battery Level

Firmware Version In Robot

Version 1.09 is up to date as of this workshop date
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Writing Programs

Easy as 1,2,3,4,5...

1. Design: Think it through first. Write it down.
2. Make the program: Drag blocks onto the program window and configure them. Connect them up.
3. Comment your code in the program window
4. Run program and debug / calibrate (optimize)
5. Save and organize your projects and experiments
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Robot Connection Window – Outputs

- Medium Motor
- Large Motor
- Display something
- Make Sounds
- Turn Pushbutton Backlight on/off
- Tank Control (Similar to Steering Block)

Steer and Drive Robot
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Main Robot Driving Control – Steering Block

Drive Mode Option

- Off
- On for Seconds
- On for Degrees
- On for Rotations

Motor Ports

How Long to Drive Option

- #Rotations
- #Degrees
- #Seconds (time)

How Long to Drive (Coast/Brake)

How to Stop

Drive Mode

Steering Direction

Left/Right, Magnitude

Speed:

0..100 Forward
0..-100 Reverse

Type how far to drive in window

Based on drive mode

(degrees, seconds, or rotations)

Hard Left

Hard Right

Hard Right

Slider control

Or type value

In Window

Hint: + or -100

Spins the robot in place

Full Forward

Full Reverse

Slider control

Or type value

In Window

Speed Option
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Exercise 2 – Program Robot to Go Straight for 3 seconds

Configure:
On for seconds
Steer Straight
Go for 3 seconds
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Robot Connection Window – Flow Control

- **Start**
- **Wait** - for a Time or Until something happens
- **Loop** – Do something over and over for a time or until something happens (Do-Until)
- **Switch** – Do different things dependin on the situation (if-then-else)
- **Loop Interrupt** - Get out of loop and go to next block
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## Programming Logic vs Daily Life

### Daily Life View

If you finish your dinner, 
**then** you get dessert,  
**Or else**, you don’t get dessert

### Logic View

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinner Finished?</td>
<td>Dessert Situation</td>
</tr>
<tr>
<td>True</td>
<td>(Check) Dessert time!</td>
</tr>
<tr>
<td>False</td>
<td>(X) No dessert!</td>
</tr>
</tbody>
</table>

### Daily Life View (Continued)

If you finish your dinner **and** do your homework, **then** you get to stay up late,  
**Or else**, bed at normal time

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
<th>Homework Done?</th>
<th>Bed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinner Finished?</td>
<td>Homework Done?</td>
<td>Bed Time</td>
<td></td>
</tr>
<tr>
<td>False</td>
<td>False</td>
<td>(X) Normal Time</td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>False</td>
<td>(X) Normal Time</td>
<td></td>
</tr>
<tr>
<td>False</td>
<td>True</td>
<td>(X) Normal Time</td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>True</td>
<td>(Check) Stay up Late!</td>
<td></td>
</tr>
</tbody>
</table>
## Ev3 Robotics Programming 101

### Different Ways to Express Logic Variables

<table>
<thead>
<tr>
<th>English</th>
<th>Logic</th>
<th>Binary</th>
<th>Electrical</th>
<th>EV3 Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>True</td>
<td>1</td>
<td>On</td>
<td>Checkmark</td>
</tr>
<tr>
<td>No</td>
<td>False</td>
<td>0</td>
<td>Off</td>
<td>X</td>
</tr>
</tbody>
</table>
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Robot Connection Window – Loops

A loop runs
The blocks inside
Until the conditions
Are met

Condition
Block – Loop
Runs until the condition is met (“True”)
Click to select condition

This block runs next when
the loop is through

Loop can end based on:
Sensor inputs
Brick button inputs
Motor rotations or power
Time in seconds
# of times through loop
Never (infinity loop)
Something elsewhere in
The program is True/False

Click to select condition

Condition Pull down Menu

Block(s) inside
the loop

Sensor inputs
Gyro Sensor
Infrared Sensor
Motor Rotation
Temperature Sensor
Timer
Touch Sensor
B tack Sensor
Energy Meter
NXT Sound Sensor
Messaging

# Count
Logic
Time

Cooke STEM Academy
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Robot Connection Window – Switch

If ultrasonic distance sensor reading is greater or equal to 12”, drive forward for 1 second, otherwise stop.
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Robot Connection Window – Sensors

- Read Push Buttons
- Read Color sensor
- Read Gyro (angle) Sensor
- Read Motor Rotation
- Read Touch Sensor
- Read Ultrasonic Distance Sensor
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Robot Connection Window – Sensors

Tells you how bright the surrounding light is as seen by the sensor
0=Dark
100=Sunlight

Tells you what color it’s looking at
Most commonly used for color sorter

Most commonly used for line follower
Tells you how much light put out By the sensor is reflected back to the sensor
0=No reflected light (black target)
1…99 Partial reflected light
100=All (white target)
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Robot Connection Window – Math and Logic

- Read Or Write A Variable
- Read Gyro (angle) Sensor
- Do Logic And, Or, Not
- Do Math add, subtract, multiply, divide, others
- Compare Two Values
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Putting it all Together – Zig Zag Line Follower

Logic: If sensor value is below threshold
Turn left, else turn right. Continue in a loop forever.

Hints: Measure sensor values on white and Black using the robot port view window, and set the threshold half way between

---

Loop 1st time

Loop 2nd time

Loop 3rd time

Loop 4th time
Exercise 3 - Zig Zag Line Follower Programming Steps

1. Make a Loop, and decide how long you want it to run

2. Make a switch inside the loop

3. Set the loop up to measure reflected light compare, and set your threshold

4. Decide how hard to steer, how fast to move the robot, and how often to move through the loop by setting # rotations/degrees/time

5. Stop the robot when the loop runs are complete
Why Line Following?

1. Line following can make sure you don’t get lost due to too much error

2. Decide what navigation method is best depending on the mission
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Dead Reckoning

Dead reckoning = Navigate by Direction and Distance

1. Go Straight x”
2. Turn Right
3. Go Straight y”
4. Turn Left
5. Go Straight z”
6. Turn around
7-11. Reverse steps 1-5

x, y, and z are variables

Start and Finish (Base)

FLL Hydrodynamics Mission Field
## Debugging

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Fix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don’t know! Doesn’t work!</td>
<td>Build up the program in sections, and test those separately. Get help from classmate or instructor. Write to the display or program robot to make sounds along the way.</td>
</tr>
<tr>
<td>Program stuck in a block</td>
<td>Check conditions to exit block. Check the program progress flashing in the blocks.</td>
</tr>
<tr>
<td>Sensor too close or too far away from target</td>
<td>Test sensor values with port view against the target. Write down values and make sure they cross the threshold.</td>
</tr>
<tr>
<td>Motors don’t move</td>
<td>Make sure Motors plugged into A-D port. Make sure program block uses same port.</td>
</tr>
<tr>
<td>Sensor inputs don’t work</td>
<td>Make sure Sensors plugged into 1-4 port. Make sure program block uses same port.</td>
</tr>
</tbody>
</table>
Dealing With Variation, Error, and Tolerance

- The robot will never move or take exactly the same path twice. This is called variation.
- A sensor will seldom read the real exact value. This difference is called error.
- The amount of variability and error which still allows your program to work is called tolerance.
- Calibration is an effective tool to reduce error and bring the robot’s behavior into tolerance.
- Calibration involves changing numbers up or down using a process called iteration.

Run experiments to discover these things and learn how to calibrate your robot.
Contact Information Programming Questions

• Email: robertcameronjones@gmail.com

• Phone (after 6PM please): 248.921.9892
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Programming Environment – Programming Window

- Back to Lobby
- Current Project
- Current Program
- Program
- Program Block Menu
- Other Project Programs
- New Program
- Program/Experiment List
- Select/Pan
- Save
- Zoom
- Undo/Redo
- Content Editor
- Robot Interface

Program

Ev3Robotics_ev3* x

LEGO MINDSTORMS Education EV3 Student Edition

ForwardInches_Gyro x TurnRight x BackUpInches x TurnAroundTemplate x