Antiviral Dispenser

Engineering 112-508

Teams 17 & 18

April 28, 2016

**Executive Summary**

During a time of crisis, such as the one that occurred with the Ebola outbreak, it is important to minimize the disaster as much as possible. To help accomplish this, a pellet dispenser can be designed to minimize the number of humans that come in contact with the devastating disease.

The purpose of this design process was to develop a prototype that dispenses the proper dosage of antiviral medication to a well to help prevent and treat ebola in a “hot zone”. This device would read four barcodes and dispense the proper number of pellets based on what the barcode dictated. This antiviral delivery system will help prevent Ebola from spreading further.

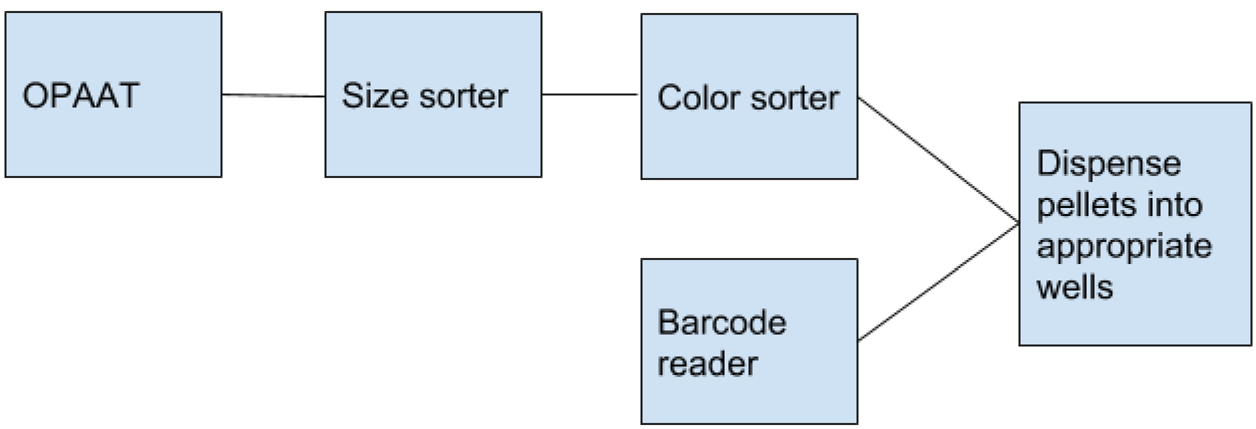
During the final performance test, the prototype completed all tasks with a few errors. A malfunction with the software caused the barcode scanner to save data from one barcode twice and output the correct pellets, but twice as many as needed, and eliminate one barcode’s necessary pellets completely. This could be fixed with a tweak in the code that stores the data from the barcode in case an error, such as the above, occurs. The prototype also had a malfunction that caused the color sensor to read the pellets incorrectly. This could be solved by providing adequate and equal lighting throughout the area where the color is read. A benefit of this system is that it is small and compact which allows the prototype to be transported easily by a single person. The prototype also only requires one person to load the barcodes, and in the future, this could be changed to where no people are needed to load those barcodes each time. Another benefit of this design is there is a mechanism that causes only one pellet to be dispensed at a time, which prevents jams and reduces the need for maintenance.

## Introduction

A new strain of Ebola has emerged from crab eating macaques and has began to infect the human population. Unlike the currently known Ebola strains, this one is also transmitted through air and contact and still highly contagious. A combination of antivirals have proven to be effective in controlling the symptoms of the virus. However, due to its airborne nature, the treatment is still facing a large challenge of how to deliver the antivirals to patients. The current solution is for the nurses administering the drugs to wear isolation suits but this limits the amount service that can be provided. World Health Organization has developed a plan to overcome the epidemic by quarantining those affecting in a defined area, delivering the antivirals through wells, and treating female macaques with immunovaccine porcine zona pellucida. Team 17 and 18 has been tasked with developing a prototype for the antiviral dispenser. Biomedical researchers have developed a stable form of the antivirals that can be contained in water for up to 24 hours before they are no longer effective. Another group of engineers are developing robots to test water quality and produce bar cards for the dispenser to know which well each pellet should be released in.

**Design Goals**

The finished prototype for an antiviral delivery system will deliver a specified number of pellets into a well at regular intervals to improve the water quality based on instructions from a series of barcodes. The prototype for the dispenser will be able to operate in an environment where human interaction is not advisable. The prototype must be able to read multiple barcodes, identify different pellets, and dispense the proper combination of pellets at regular intervals. The prototype should also discard all unnecessary pellets that may be toxic or simply unneeded for the specific dosage dictated by the barcode. The functional block diagram below shows the process of the final prototype for the separation of pellets. The pellet will first go through the OPAAT, then the size sorter. From there the pellets will go through the color sorter and finally be dispensed into the appropriate wells based on what the barcode requires.



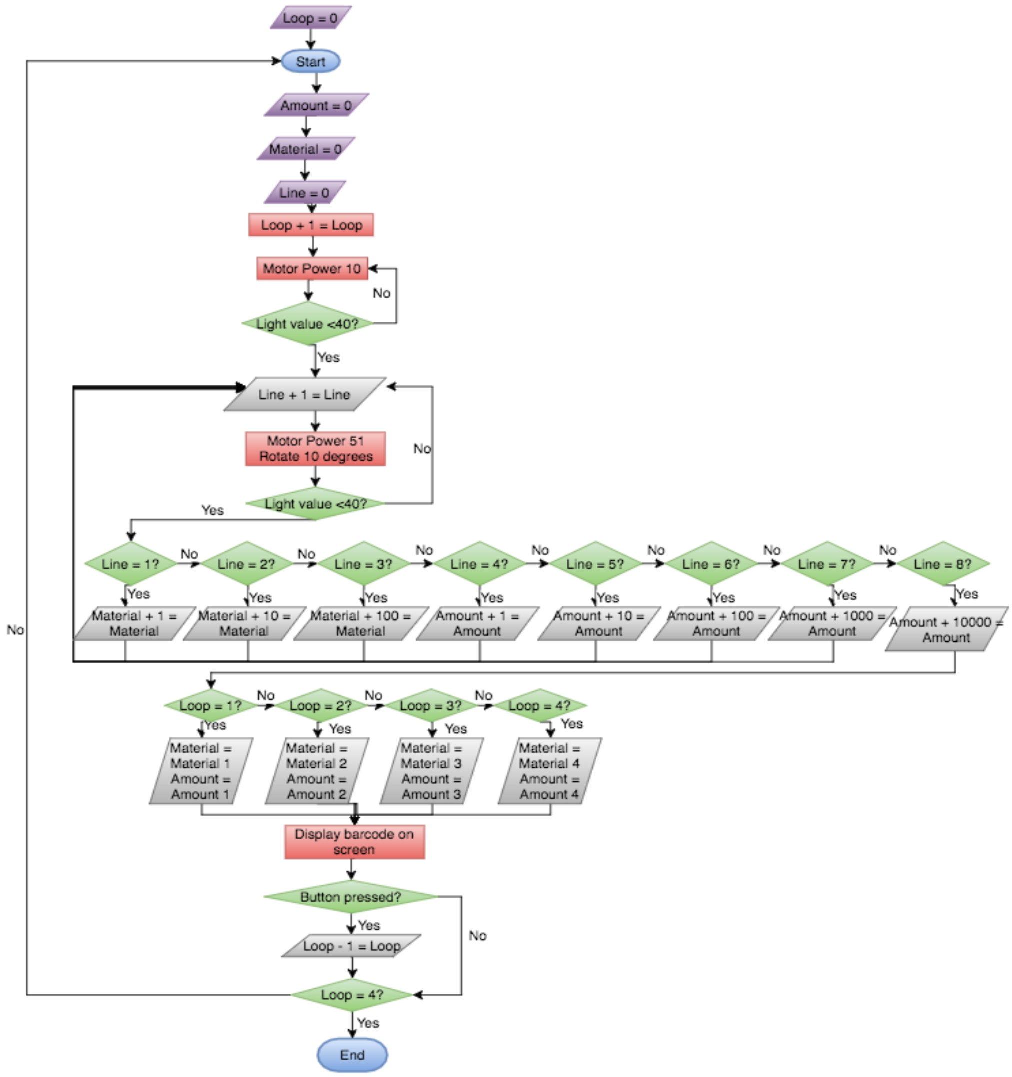
**Design Development and Discussion**

Throughout the progression of this prototype, many different designs were developed and considered for the final design. In the first subtask, the goal was to develop a system that would hold 75 pellets and dispense pellets individually. To do this Team 17 & 18 both developed their own designs. These designs were later combined for subtask two where the best parts of each design were used to create a better overall system. The windmill mechanism was taken from Team 17 and the pellet agitator from Team 18. By combining these systems a design was developed that ensure no pellets were jammed at the beginning of the system and that pellets were dispensed individually.

In subtask 3 the windmill was determined to no longer be suitable because the pellets also needed be dispensed so that the size and color can be determined. Due to the windmill dispensing the pellets to the side and close to the ground there was not much room for transport to color sensors or size determination. To accommodate for this a new design was developed. The new design included a tubing system that delivered the pellets to a size sorter where there were tracks that would release small pellets to a track below and leave larger pellets on the top track. Large pellets were then transported to a conveyor belt where they were carried individually to a color sensor for color to be determined. The small pellet track led to a weight distribution system. This system was created because of the issue where green and steel pellets were read as the same by the color sensors as well as the white and HDPE pellets. The weight distribution system worked so that the heavier steel pellets would be delivered to a separate track on the left, the lighter HDPE pellets to a track on the right, and the colored pellets in the middle that led to a track and conveyor belt system similar to the large pellets. Subtask 3 also included the first design of the barcode reader that was designed to take in four barcodes and display what pellets should be dispensed into the viable well. A unique asset to the barcode was that it had each of the various cases already stored. This way if a barcode was read incorrectly, an error message would be displayed and the barcode could be ran again rather than completely starting over.

Moving on to the final prototype, pieces of each of the previous designs were used. Having many different tracks in subtask 3 introduced the problem of how pellets from four different tracks would be able to be transferred to the correct well. The final prototype included the initial agitator, the size sorter, barcode reader, and one pellet at a time dispenser from subtask 3, and a moving track inspired from the windmill mechanism in subtask 1. To keep the overall system more concise, smaller tracks were made and the pellets were dispensed individually into the size sorter. From there the color was determined and dropped to a track that would move based on if the pellet was toxic, not necessary, or the a correct pellet based on the barcode reading. The issue of similar color readings from the small pellets was overcome by including a flashlight that directed light to the color sensor and gave a more accurate reading. By creating multiple designs throughout the progression of the prototype, Team 17 and 18 were able to take the best parts of each design in the final prototype and create a more reliable system.

Barcode Reader




In order for the whole prototype system to run smoothly, the mechanical portions and the software had to run together with minimal errors, or achieve the objectives as often as possible. The programming portion began with Subtask 3, in which a barcode scanner was added. The barcode scanner included wheels attached to motors that would provide traction to the barcode and would run it by a certain amount 8 times, testing whether a possible line was black or white, then adding the respective binary value to the appropriate variable as necessary. A high-pitched beep would sound if a black line was read, and a low-pitched beep would sound if a white line was read. Text would be displayed on the screen indicating what color, material, and how much of each type of pellet the barcode that was read called for. If, for some reason, the barcode was read incorrectly, determined by the user either by the pitches of the beeps that sounded as the barcode was scanned, or the text displayed on the screen indicating what was read, the user would be prompted either to wait in order to move on to the next barcode, or to press a button in order to redo that barcode, which would reset a “Loop” variable that indicated which barcode of four was being read and saved. This helped to eliminate any errors that could possibly occur by introducing the incorrect dosage.

In the final demo, the barcode scanner was connected to the rest of the system. The barcodes would be read in the same way as in Subtask 3, and the binary code would be saved to four variables. These variables were then deciphered and translated into new variables that included how much of each type of pellet was required. First, one brick ran a motor that ran a conveyer belt that was the O.P.A.A.T. of our final prototype, and the Funnel Agitator that helped mix the marbles in the funnel in order to eliminate any possible jams. A separate brick was connected to the barcode scanner, two color sensors, a gate, and a pellet dispenser.

Once the variables were saved from the barcode information, the marbles would begin to run through the system. As the color sensor on the top of the size sorter sensed a marble, the color would be determined, and, for example, if the color was blue, a value of 1 would be subtracted from the value in the variable containing how many large blue marbles were needed. The gate would then lift to release the marble onto the pellet dispenser, which acted as a ramp. The ramp would move a certain amount clockwise in order to dispense into the bin that contained the pellets needed for the dosage. It would then rotate the same amount counterclockwise in order to reset itself. This would occur until the value reached 0. After this, the pellet dispenser would not rotate once the gate was lifted but would rather maintain its position so the pellet would dispense into the bin that contained pellets that were valid but were not needed in the dosage. If the pellet read by the color sensor was toxic, however, an alarm would sound, and the pellet dispenser would rotate a certain amount counterclockwise to dispense into the bin that contained toxic pellets. It would reset itself after this as well. The same occurred on the bottom color sensor that sensed small marbles. Once all of the variables reached a value of 0, the brick would sound a series of beeps indicating that the correct dosage was dispensed. The system could be stopped with a simple press of a button to end the program.

**Results**

In subtask 1, both team's prototypes performed well as seen in the data table included as Subtask 1 Ratings. Both teams had difficulties handling the large number of pellets put in. Both teams experienced pellets getting jammed in the contraption built to hold the marbles and thus no pellets were released onto the track. The OPAAT design from team 17 was later used for subtask 2 as well.

Subtask 2 went well, however one pellet was too large to fit through the tube designed to prevent jamming of multiple pellets and would not pass through. However, the prototype worked almost perfectly when that specific marble was removed from the mix. The prototype would dispense one at a time almost 100 percent of the time but sometimes would dispense two small pellets at the same time.

Subtask 3 showed that the barcode reader mechanism needed to be improved so that the mechanism could accommodate cardstock rather than average computer paper. The pressure the wheels placed on the cardstock caused the barcode reader to move the cardstock too far and the readings were therefore offset by the extra thickness of the cardstock. The mechanism for separating color and size however worked perfectly.

In the final demonstration, the prototype did very well. However, there was a malfunction that caused one barcode to be stored twice, so twice as many pellets of that kind were released. This could be fixed with a tweak to the code. Also, a better product would include the ability to halt dispensing if the proper dosage cannot be made and a way to reroute all of the pellets to the top of the system so that no pellets were wasted.

**Recommendations/Plans for Future Work**

To improve the prototype's design, it would be more efficient for the system to sort the pellets by type into separate bins prior to dispensing the dosage. A value of 1 could be added to the respective variables each time a pellet is sorted. After all of the marbles have been sorted, the barcodes could be fed into the barcode scanner, and then the system could simply release the necessary amount into the well, subtracting values from variables as needed. If the value of a variable was less than a required amount indicated by barcodes, an alarm could sound, keeping all of the pellets that it has rather than dispensing as it goes only to find it cannot complete the dosage later. This would provide more ease with sorting and software, and it would be more cost-efficient than throwing away viable pellets that were unneeded for the first dosage. Another improvement that could be made to the prototype is to construct it out of sturdier materials so that it lasts longer and does not need to be repaired as often.

In order to solve the issue with the inconsistency of the color sensors, they could be placed inside of a closed system, with an artificial light inside. This would keep light values consistent and not as reliable on natural light or other light in the surrounding environment. Errors would be sent once the system sensed that the light no longer worked to indicate the need for replacement.

In regards to the barcode scanner, a more reliable method for reading the barcodes, such as a laser barcode scanner that would read the barcode within a fraction of a second that would just be held up to the light and not require movement in that regard and compare the light values to pre-programmed graphs of light values that corresponded to their respective barcodes could be implemented in the future to eliminate the need for redo option.

Another option would be to eliminate the need for barcodes completely and to be able to have a tablet or similar device that could send information to the sorting system. A person could select how many of each type of pellet is needed on the tablet and then send the information through bluetooth once it has been confirmed that the dosage is correct. The system would then dispense as needed.

**References**

[1] Unknown. (2016, January). *Ebola Virus Disease* (Fact Sheet Nº103) [Online]. Available: http://www.who.int

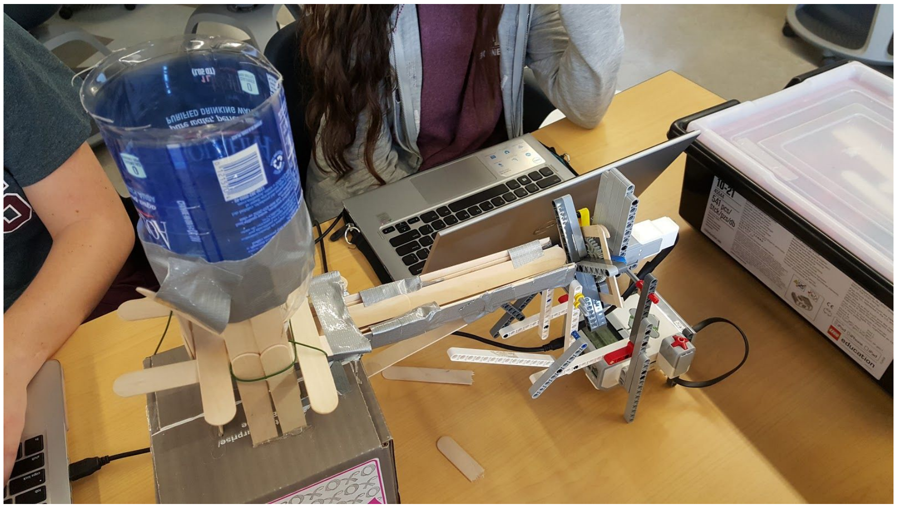
[2] Unknown. (2016, February 18). *About Ebola Virus Disease* [Online]. Available: http://www.cdc.gov

[3] Susannah Cullinane and Madison Park. (2015, July 31). *Ebola Virus: Nine things to know about the killer disease* [Online]. Available: http://www.cnn.com

[4] John W King, MD. (2015, February 17). *Ebola Virus Infection* [Online]. Available: http://www.emedicine.medscape.com

**Appendix**

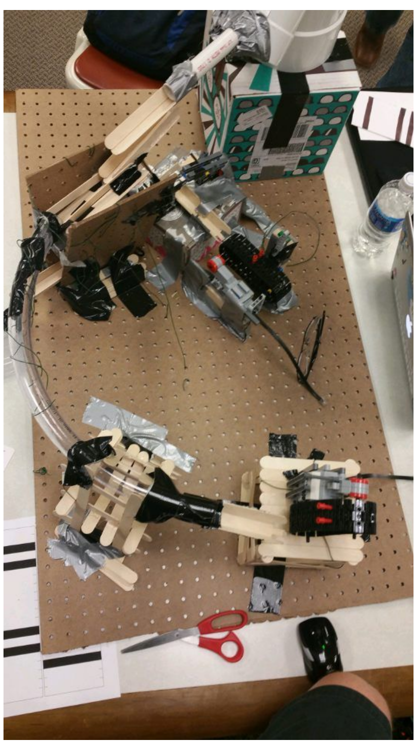
Team 17 Subtask 1



Team 18 Subtask 1

Subtask 2

Subtask 3

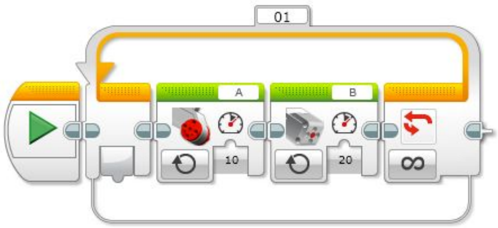


Final Demonstration

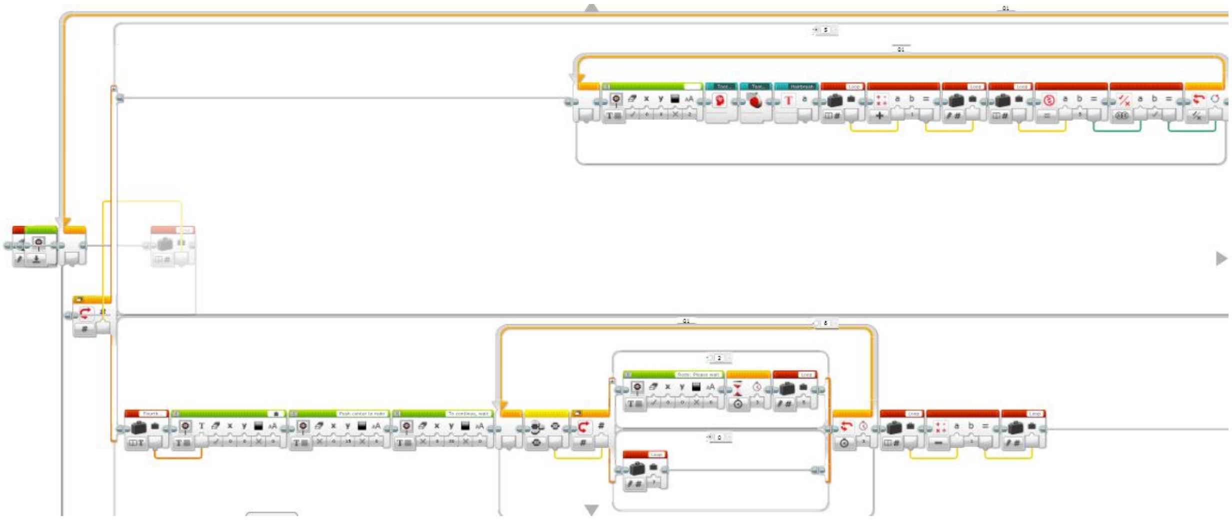
Subtask 1 Ratings

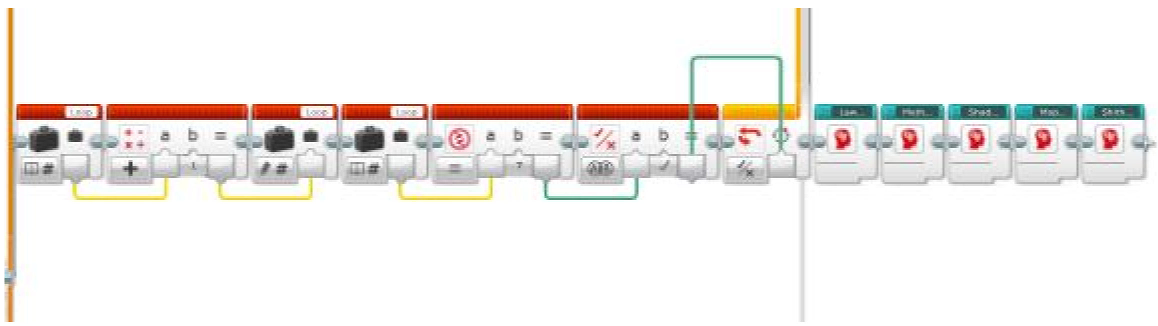
| Role | Color/Transparency | Size (approximate) | Simulant Material | Reflectivity/ Color values |
|---|---|---|---|---|
| Water Quality Pellet Type I | Metallic | 14 mm | Low-Carbon Steel or Hollow Aluminum | >9 |
| Water Quality Pellet Type II | Blue, Opaque | 14 mm or 18-20 mm | Glass | Blue |
| Water Quality Pellet Type III | Red, Opaque | 14 mm or 18-20 mm | Glass | Red |
| Water Quality Pellet Type IV | White, Opaque | 14 mm or 18-20 mm | Glass | White >23 |
| Storage Stability Pellet | Green, Opaque | 14 mm or 18-20 mm | Glass | <9 |
| Antiviral Pellet | Translucent White | 14 mm | Polyethylene (HDPE) | White <23 |
| Unassigned | Yellow, Opaque | 14 mm or 18-20 mm | Glass | Yellow |

**Brick 2 Code**

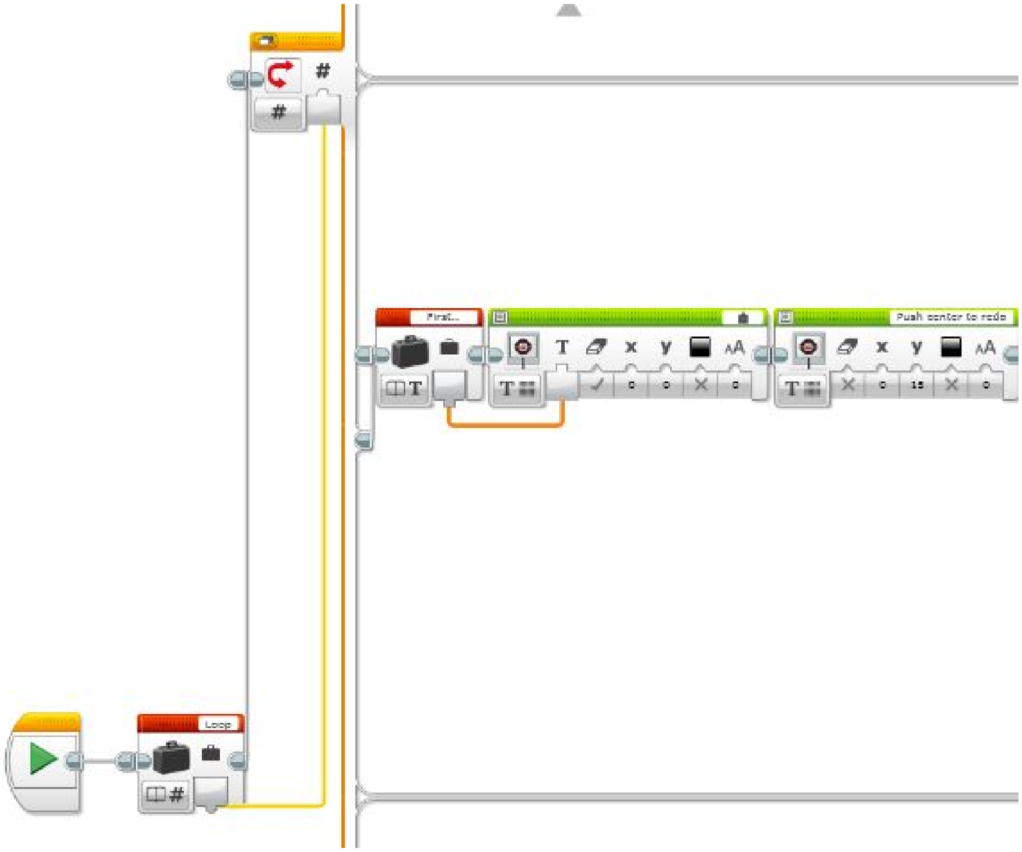


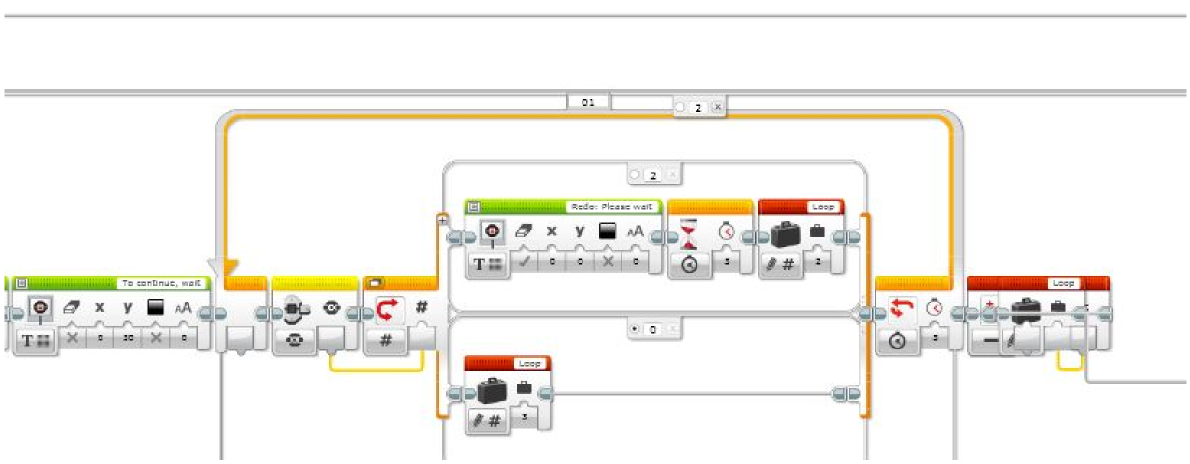
## Brick 1 Code

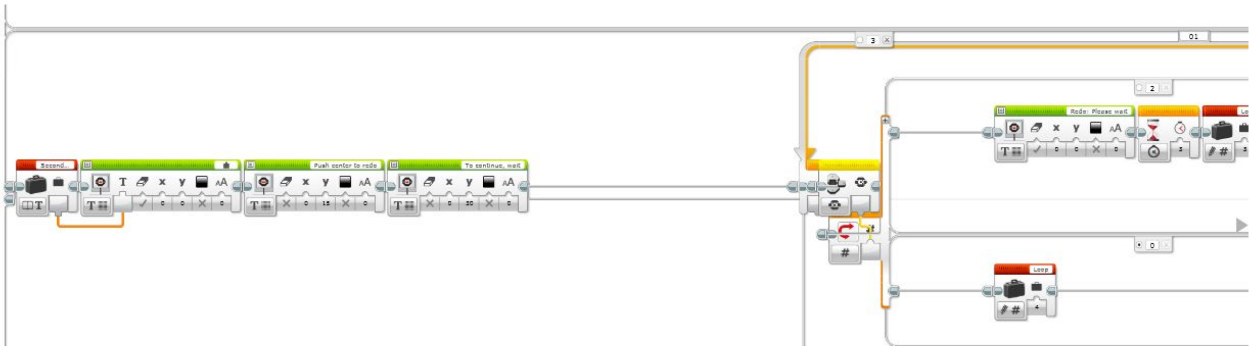


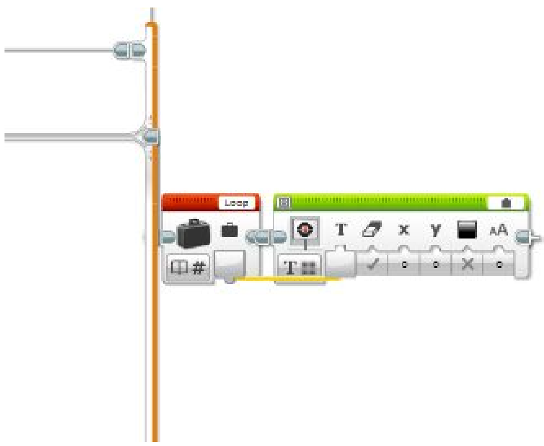


**Availability to redo on barcode scanner**

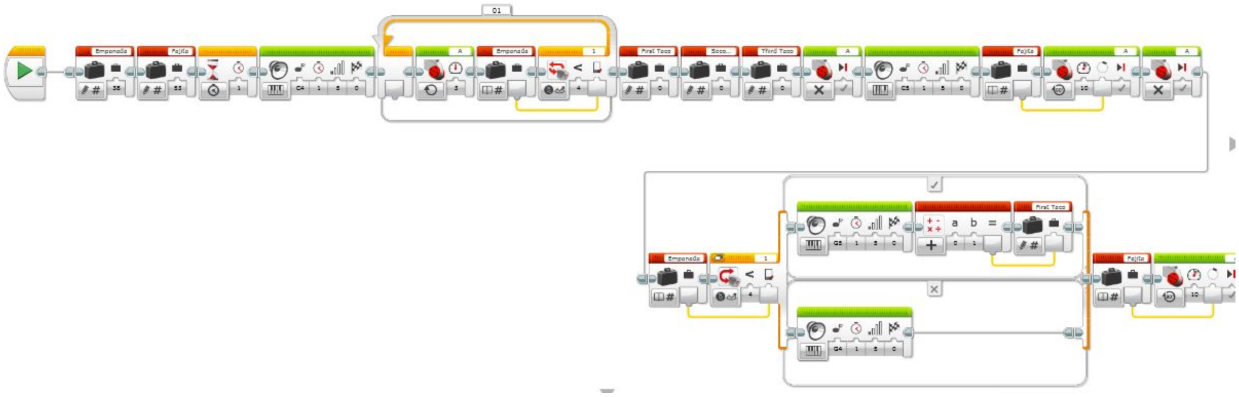


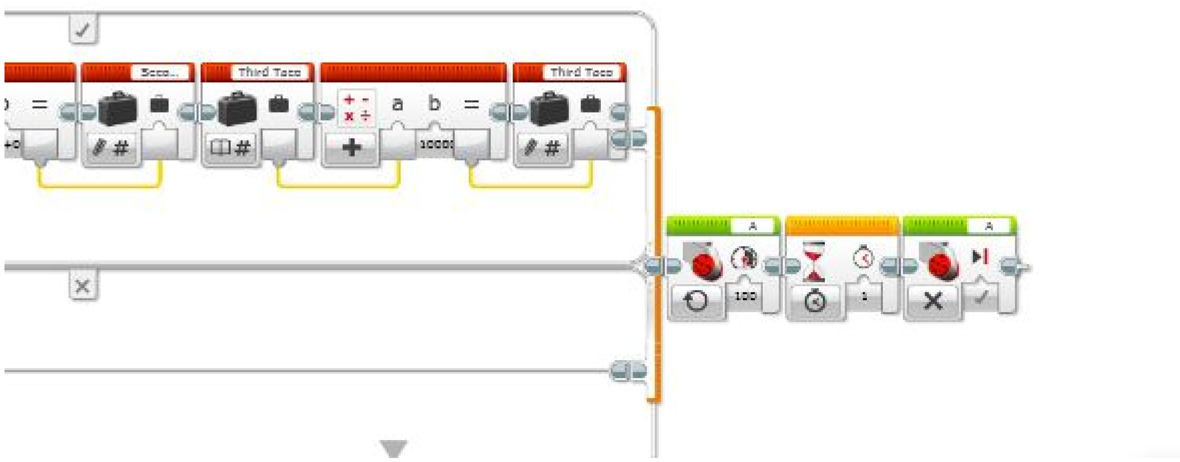





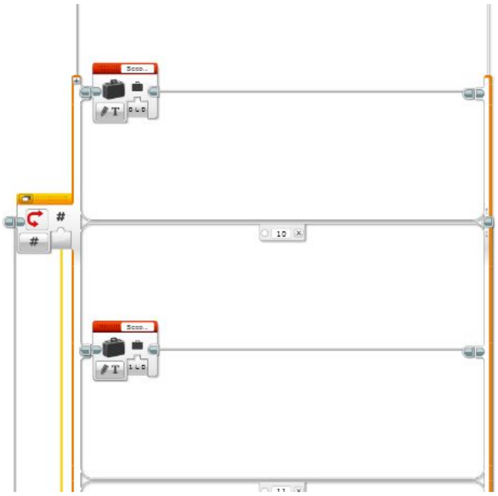

Loop

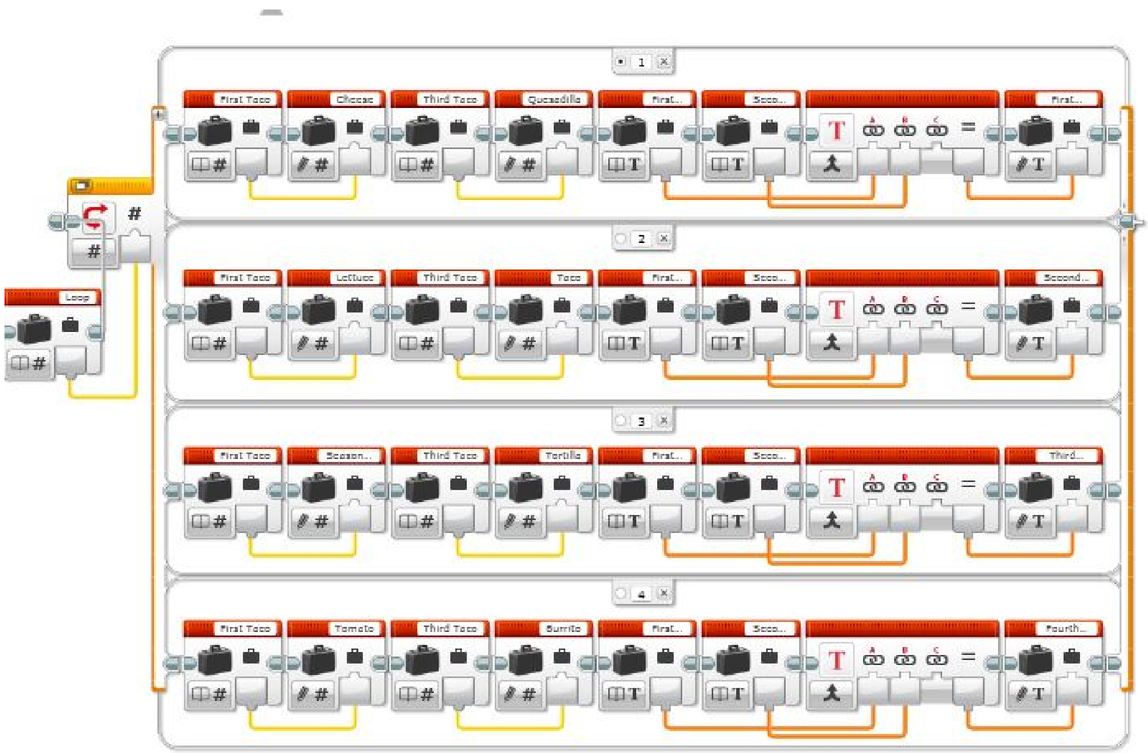
## Barcode Reader



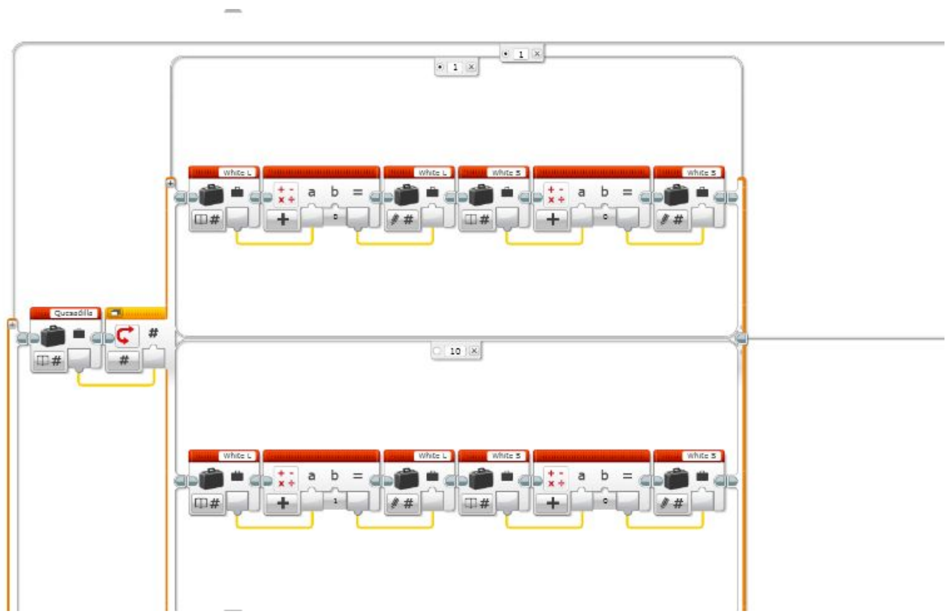


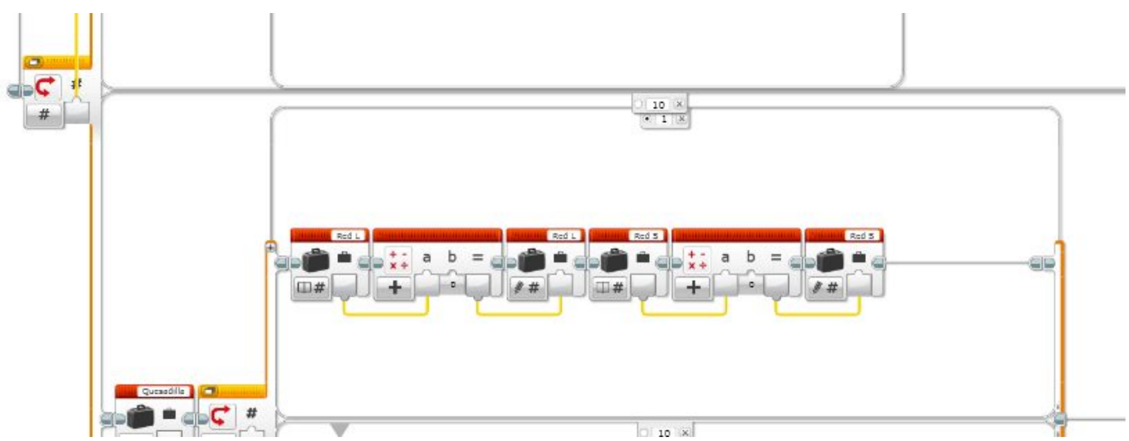
### Assign Text and Binary Code to Variables



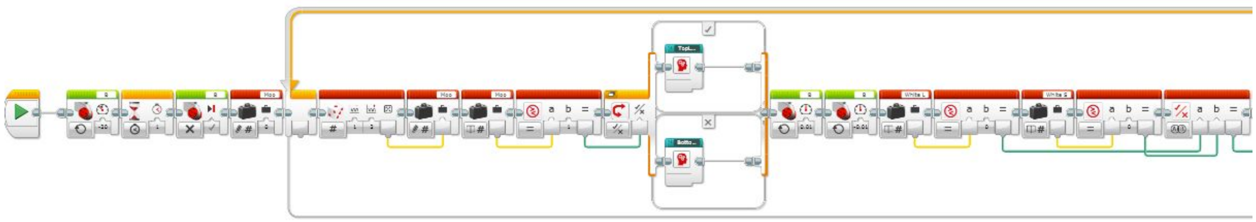


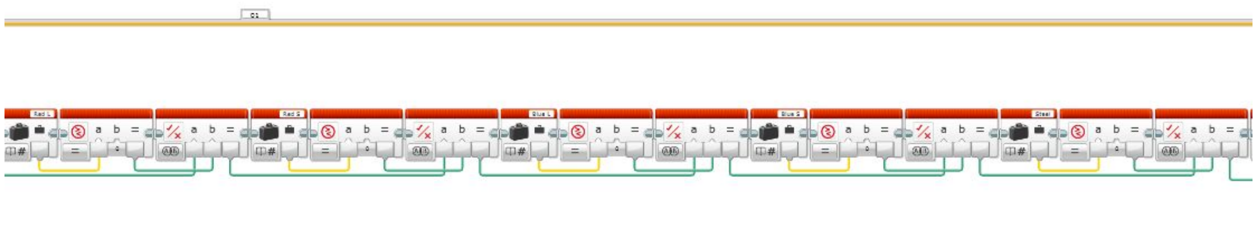
# Deciphering Binary Code to create variable with necessary number of pellets

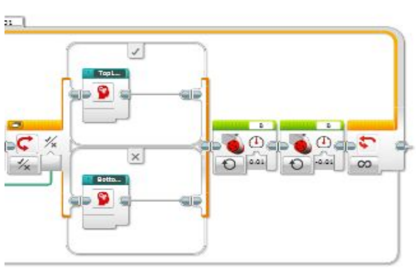





**Will run until variables all equal 0**

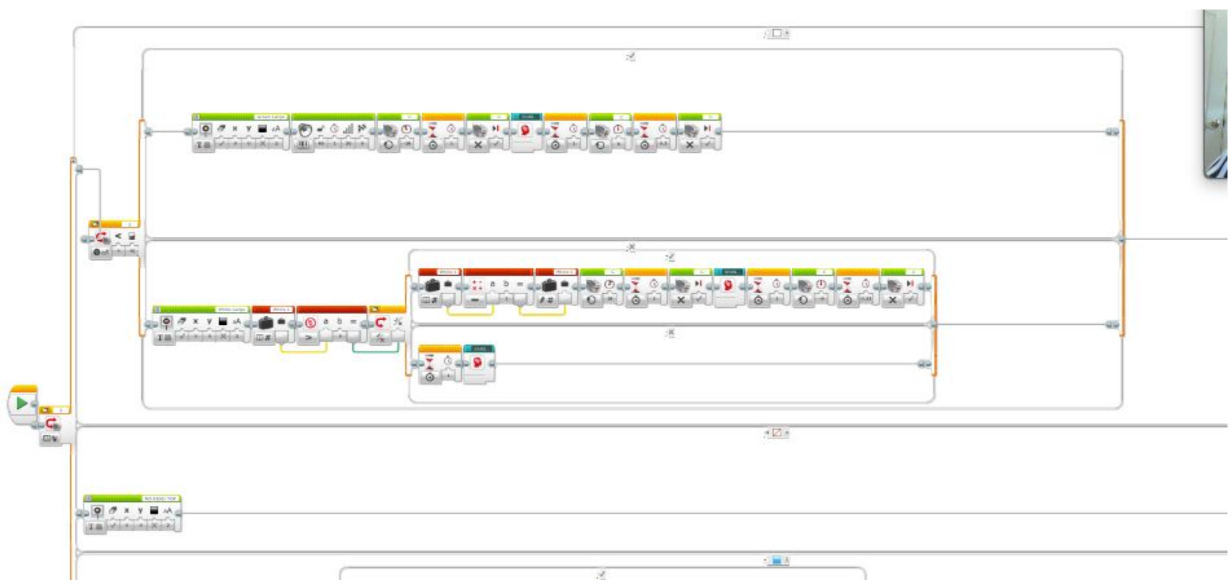




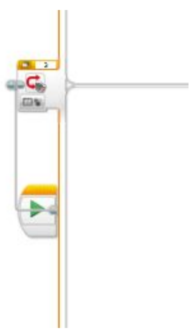


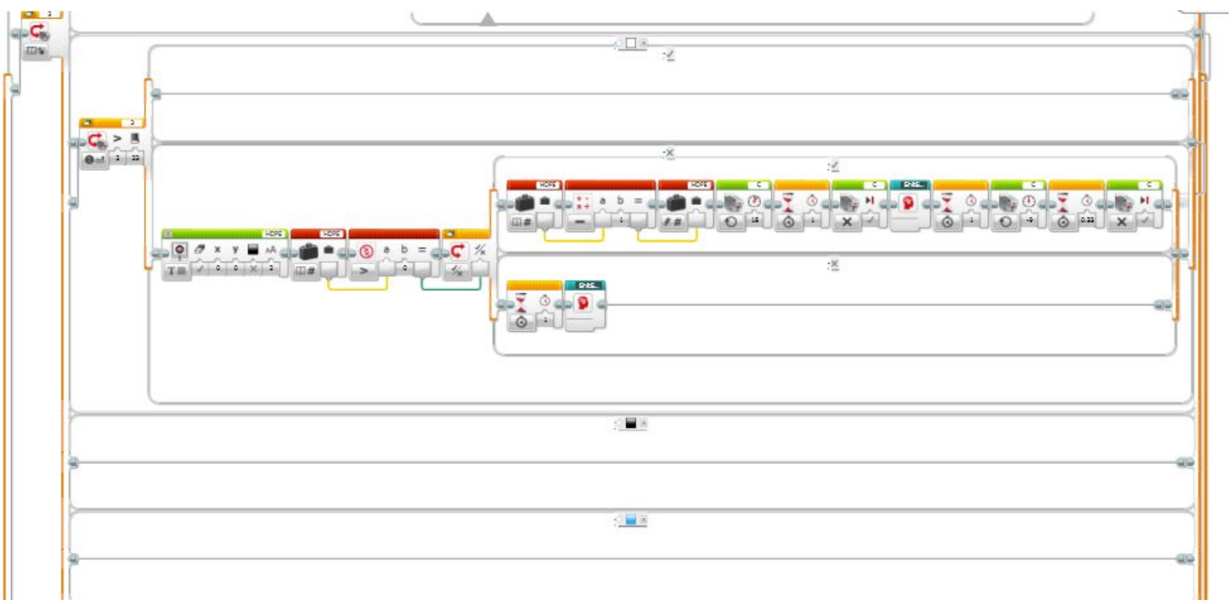
## Gate

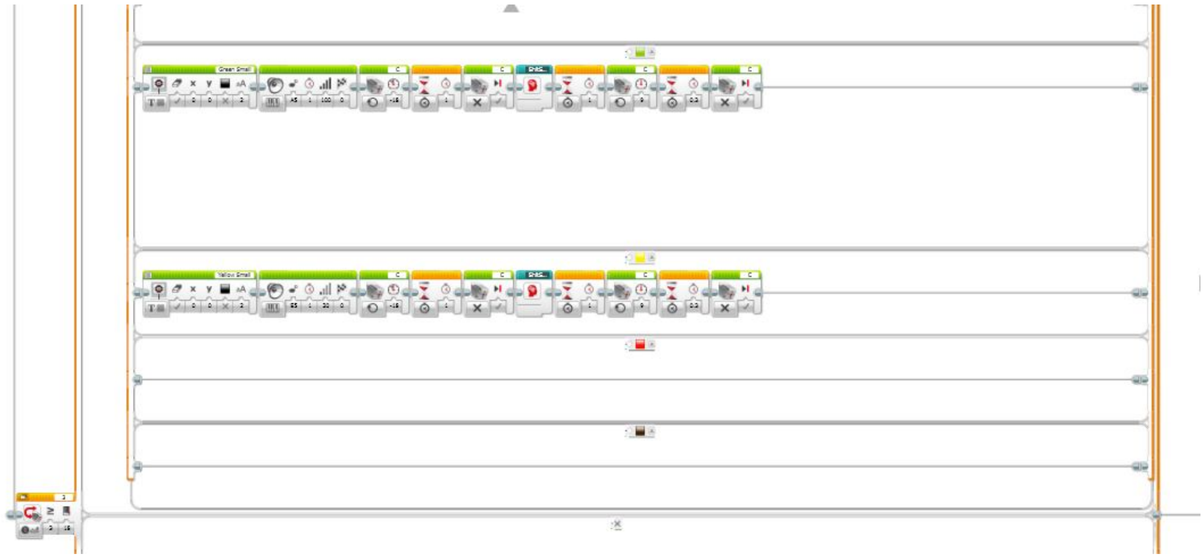

## Top Sensor

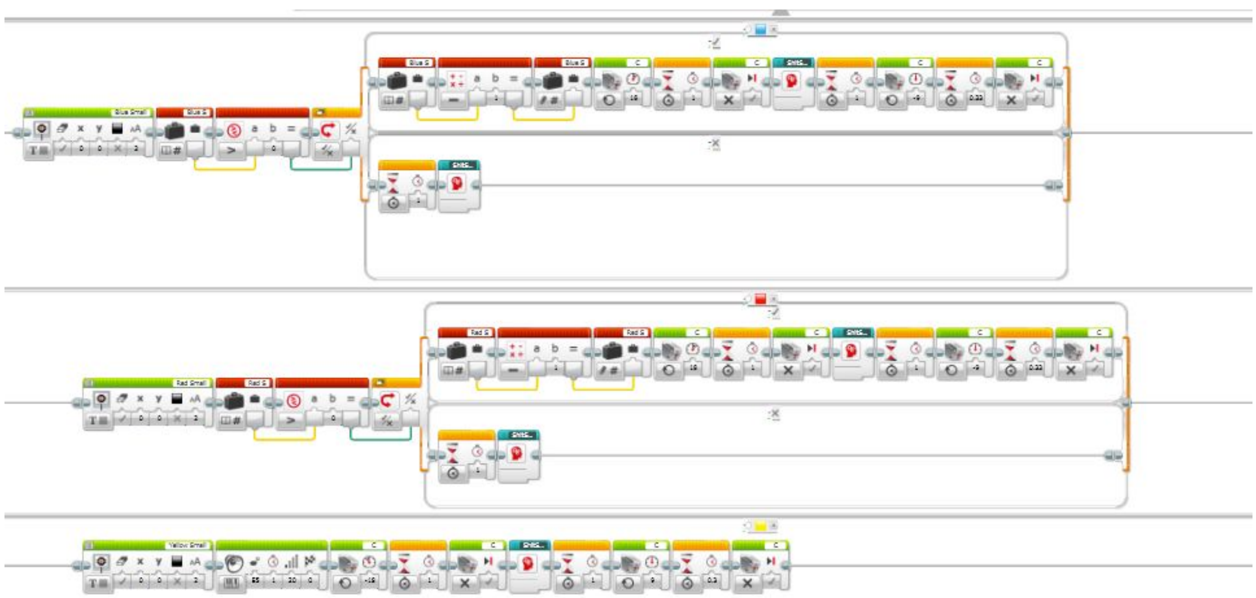


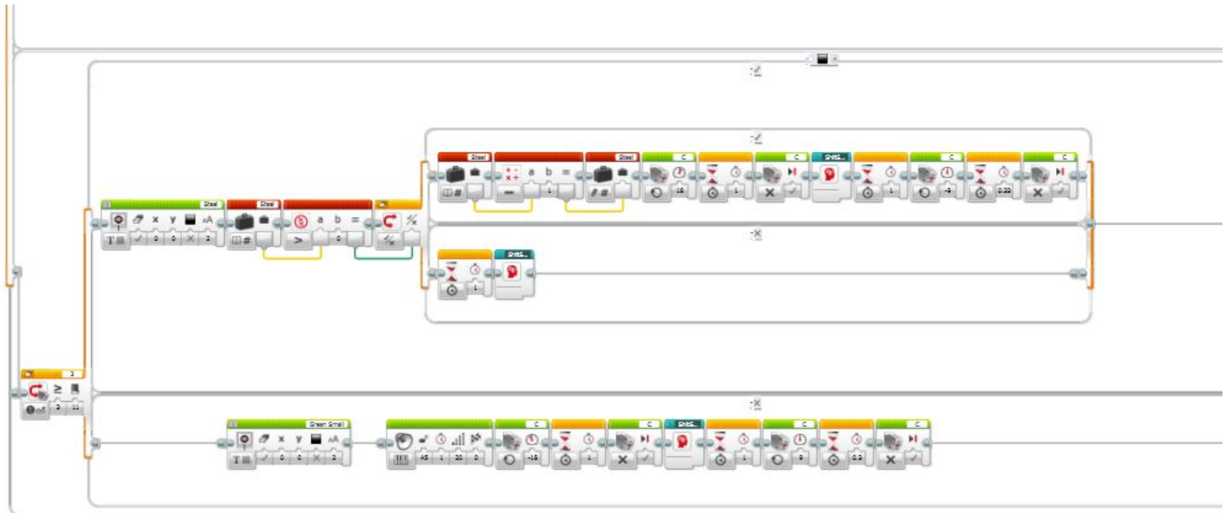

**Bottom Sensor**











Steel
Green Small