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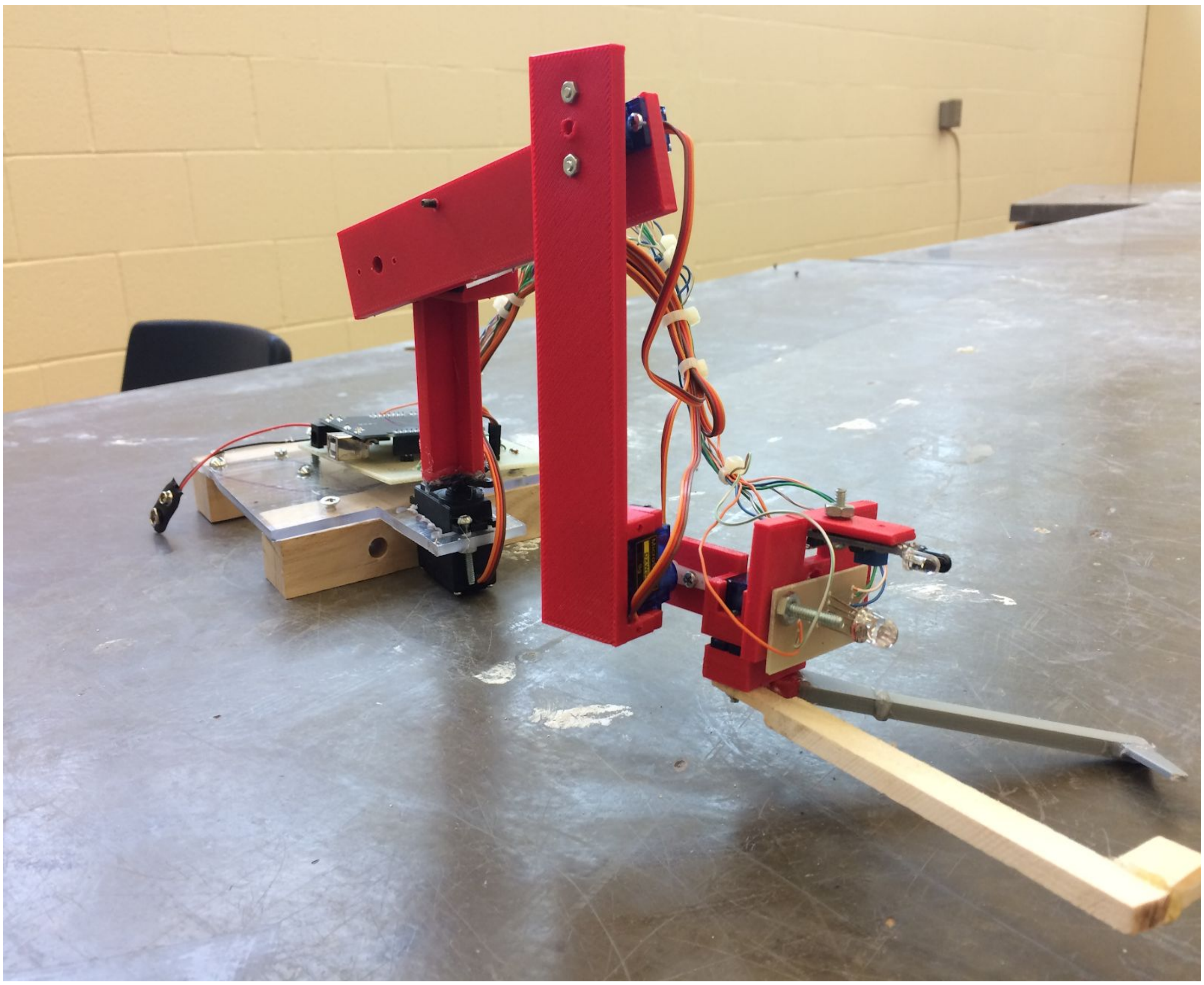
The Green Arm



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Introduction:

Overview:

In my eyes, the purpose of technology is to enhance the lives of others. Enhancing their lives can be direct or indirect, leaving a large window of opportunity for technology to make a difference. I have created my own design and robot with a purpose to be a basis of a new, revolutionary technology concept. Well, not necessarily new, but definitely a good basis for a product which has a lot of potential in my opinion. My robot is the Green Arm: it is a robotic arm that consists of mainly servos and sensors controlled by an Arduino, connected to a series of arms that has the objective of sorting different types (colours) of trash (plastic object) on a course. This green arm will move multiple plastic objects (one at a time though) and sort them into different sections with the objective of doing it as fast as possible.This is the basis of the project that I have designed, but that is just a base for what this green arm can do. Any application similar, or a whole new concept with the arm, is possible with this arm. My robotic arm is a cheap robot with power that can sort products in everyday life. This can be very beneficial to people who do not have the effort to organize their utensils (on their work desk), or the possibly their kitchen utensils, etc. Or it could be mounted onto another robot to serve a larger purpose.

My robotic Arm can move small objects within a 1.5 feet radius semi-circle. Keeping this in mind, it can be placed on a table, and registered to move small objects all around the small table. But this robot is just a small, base model of what it can actually be. Upgrading the parts will increase the cost from around $70 total, to $150 total, but it will be able to accomplish much more as it will have a lot more power, letting it be able to move more than just small objects. This concept continues with power and quality of movement, but I want to keep the robot cheap, so it can be affordable by the public. The goal of this robot is just to move and sort small items, so its specific purpose would have to be determined by its holder. If I were to have one at my house, I would have it sort my pencils, pens, markers and miscellaneous items in separate bins for me.

Design decisions:

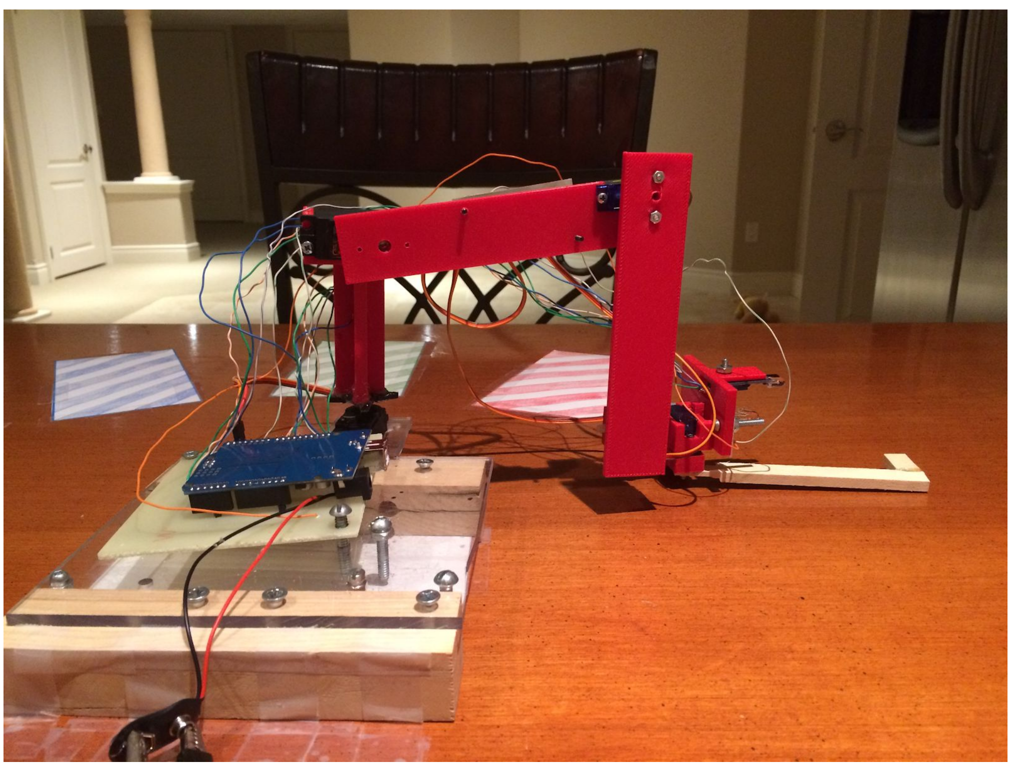
When the project is complete, there will be a 3D printed arm, consisting of 3 joints where servos will be installed to create movement. At the end of the arm, there will be a grip (controlled by another servo). There will be an ultrasonic detector (possibly) to detect barrels and there will be a colour sensor (to detect colour or alternative part if possible). These will be installed either at the base or on the arm. The board of the robotic arm will be around 4 in. by 4 in. with the arm having a total length of around one feet long.

Work Breakdown Schedule

Time Period	Work Scheduled
Sept 29 - Oct 7	Choose a design for the robotic arm, if no design is chosen, then I must CREATE a design for the robot
Oct. 7 - Oct. 20	-Print the robotic arm -Design and create circuit boards
Oct 7 - Oct 25	-Design and print the arm if there was no possible design to just print -Design and create circuit boards
Nov 5 - Nov 15	Assemble Robot
Nov 5 - Dec 1	Test Robot and make it suitable for Green Arm Challenge, as well as fix and tweak the robot
Dec 1 to TEST DAY	Tweak robotic structure and code, maybe add additional features to enhance the robot. Fix any problems that may have been occurring before.

Assumptions and Modifications:

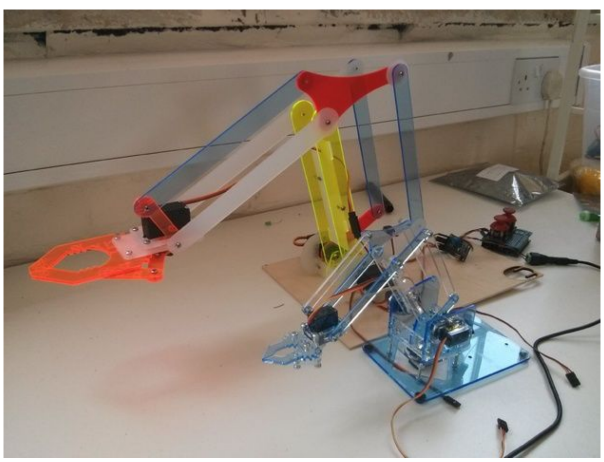
Since the robot is being made from scratch, it is expected that there will be errors in the design which will limit the potential of the robot. FIrstly, it was expected that the robot may not be strong enough to both extend and pick up a barrel due to the torque of the servos. Since the robot was declared to weak to fully extend, the course was changed to have the barrels placed closer to the arm so it could reach the barrel, and it would have to place the barrel in one spot in a zone. Also, the gripper of the robot was expected to be weak or not practical since it was designed from scratch. My gripper for my robot ended up having a long, stationary arm and another long arm that moved from a servo. This allowed the robot to grab barrels going only from left to right as the robot's stationary gripper is on its right side, so barrels will get cupped going right to left, but if it were to go from left to right, the stationary gripper would knock over the barrel, making it useless. Lastly, the power required for the servos was expected to be difficult to determine, so a controlled external power supply would have to be required. A PCB was made to solve this, but it failed, so an adjustable power supply was required to be able to control the servos and other parts of the robot adequately.

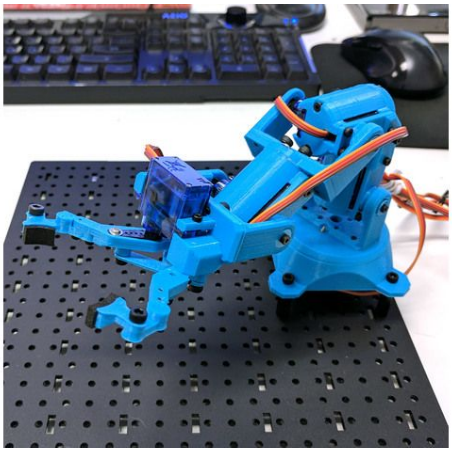
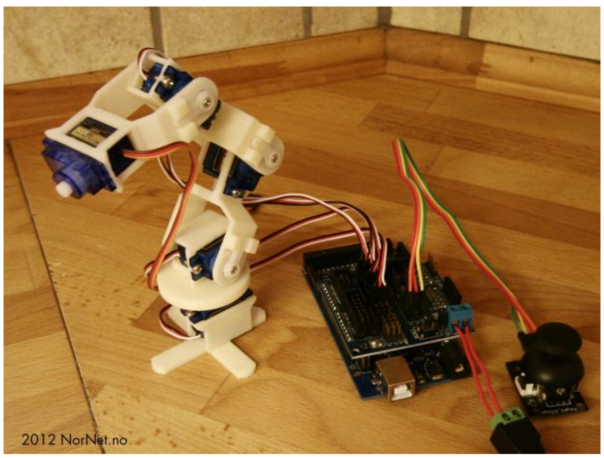


Specifics and Design:

Build Design:

There were multiple robotic arm designs that I had was considering for a week, but after extensive reasoning, it was determined that I would be better off creating my own design and implementing new designs as I progress through the project. Some reasonable designs that I was looking at were the Snapper Mini- YA9GRA, Micro Robot arm, and the meArm Max, all of which were fully 3D printable designs from other people creating robots. Although all of these designs were impressive, the main problems that occurred were the cost of the parts for the robot, the complexity of the robot, and the size of the robot. All good designed robots were very small, and the large robots had a design with limited flexibility or were too expensive. Thus, I decided to inherit some of the features of these robots and combine them to create my robot.

Robot Design	Features Inherited
	The design was very impressive and the limited number of servos used definitely intrigued me. Although, the concept of levers and wedges to control an arm were complex, so I choose this to be my limit for difficulty

	This design has a very simple design as it uses servos to manually control each pivot in the arm. However, this arm only uses 4 servos and is very small, so I wanted to make a bigger version of this robot.
	This arm is the closest to what I designed. It contains 4 servos and it somewhat bigger than the other designs, having a 30 cm radius for range. I choose to base my idea off this design as I believe it had the most potential for my capabilities.

The robot was initially designed to have only 3 joints, so three parts moving to make the robot move. However, once it was determined that 3 joints would produce a robot that was too small to meet the required distance that the robot should be capable of reaching. So another joint was added in the middle of the robot to increase flexibility and to give the robot the ability to extend the required distance. Under we have rough sketches of the original parts (the 3 joint robot), and another picture highlighting the added part to increase extending distance.

Parts List:

Part	Cost ($)	Purpose
Arduino board	13.95	Allow other electronic parts to communicate with each other and be controlled
Infrared Sensor	1.95	To see the barrel (object) in front of robot
Up to 10 resistors (220 R)	1.00	Control voltage going into electronic parts
3 micro 9g servos	8	Allow movement of parts off a pivot. Used for the last 3 pivots as they are smaller
2 tower mg servos	20	Allow movement of parts off a pivot. Use for the first 2 pivots (the base pivots) as they require more torque to move
Colour sensor	2	To see the colour of the barrel (object) in front of the robot
Copper board	-	To connect all of the parts to one central piece
Wires	-	To connect the parts to the copper board that cannot be directly attached to the copper board

Circuit Design:

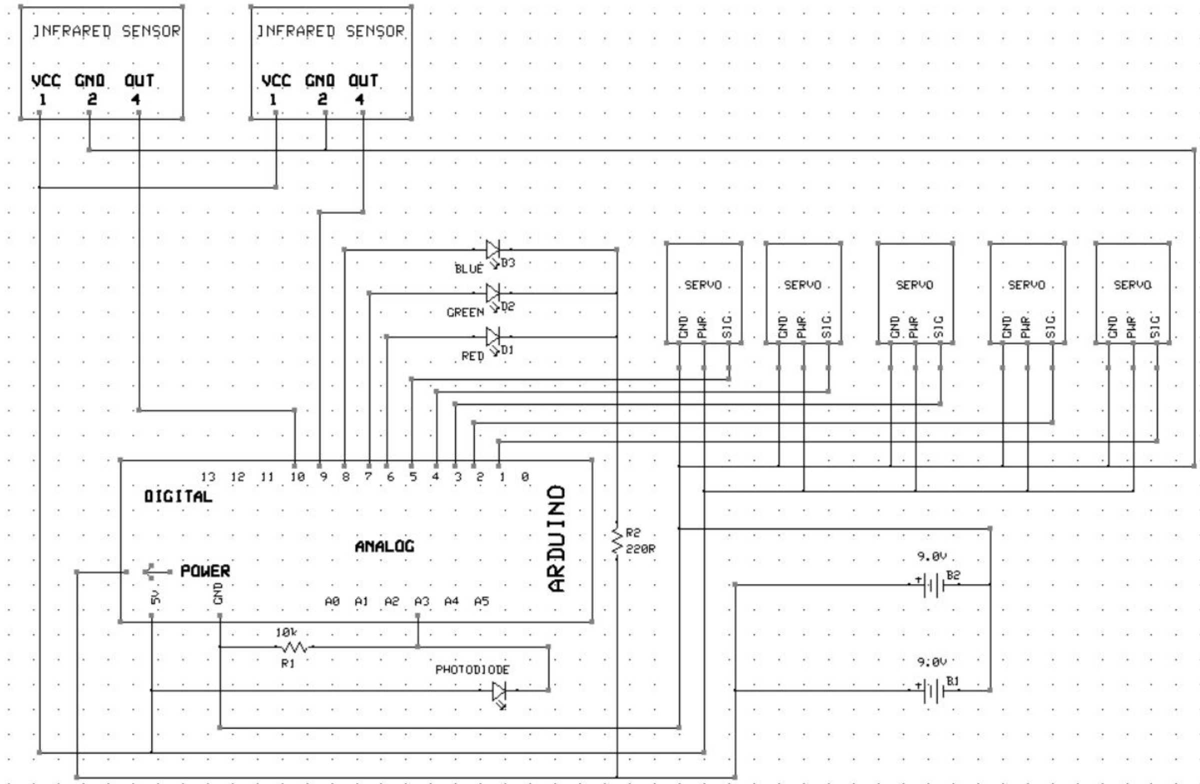
The robot uses a total of 3 circuit boards that are connected to each other, with only one the infrared sensor having an integrated circuit, but it is still connected to the other circuit boards so it can reach the Arduino and we can use its values.

The first circuit board is a colour sensor board, where an RGB light and photoresistor are connected to a few resistors and the Arduino. This board was attached to the head of the arm and the wires were extended to the main base circuit board.

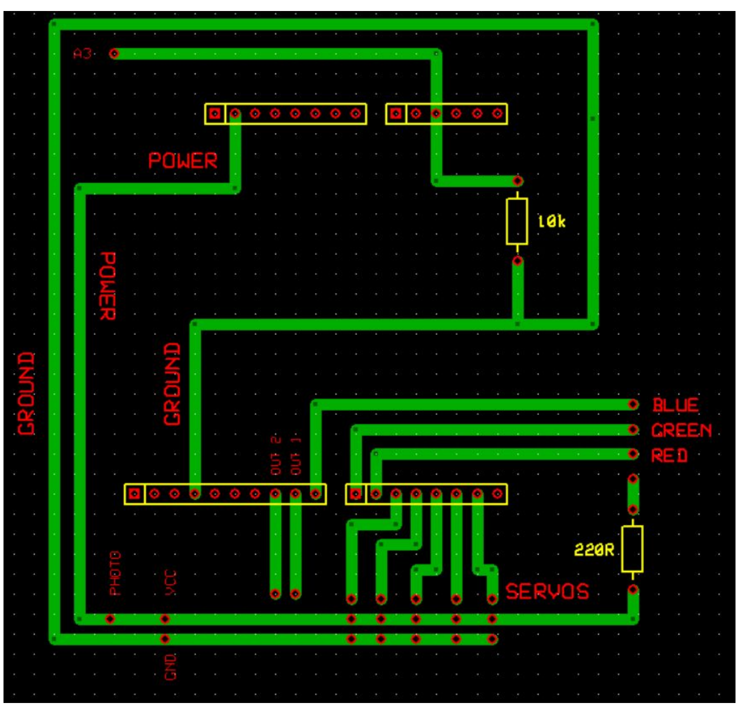
The main circuit board is the core circuit for the robot, as it connects all parts together with the arduino and power, allowing the robot to function. On the main circuit board, all signal pins from other hardware are soldered onto the board. Such hardware include the infrared sensor, the RGB light an photoresistor, and all of the servos. As well, all power ran through this circuit board as it limited the number of connections having it that way. All signal pins were aligned so that the arduino could be mounted onto the circuit board via SIPs and it could connect with all of the other parts.

The final board is a power and extension board, created primarily for the servos and colour sensor board to have 2 wires going to the main circuit board to have more secure and contained wiring. For the servos, the farthest servos from the main circuit board could not reach the main circuit board, so they had to connect to the extension board.

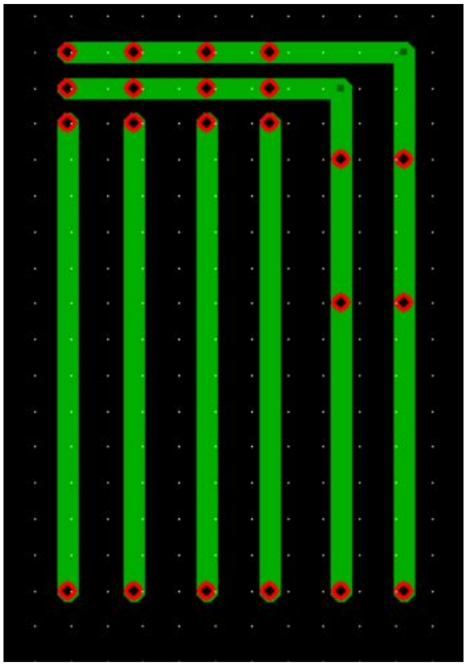
Schematic Diagram of All Circuits Connected:



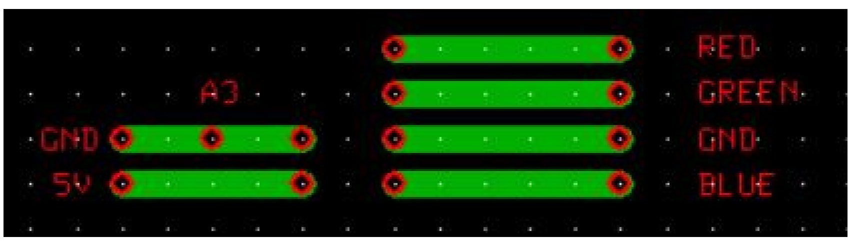
Base PCB:



Servo and Power Wire Extender PCB:



Colour Sensor PCB:



Software Design:

The software was designed to complete steps one by one and progress through the next stop after it completes the previous step as it will have the necessary information to continue. The main software code is as follows:

1) The colour sensor values are initialized
2) The robot begins is journey to look for a barral, starting from the right and moving to the left 180* in one rotation
3) When the robot passes by a barrel, its infrared sensor will activate and the robot will stop at the barrel
4) The robot will extend, pick up the barrel, pull it back, and sense its colour.
5) Once the colour is determined, the robot will go to the designated zone, and drop the barrel off at that zone.

Final Code and all code files are provided via link at the end of the document

Constraints:

There are multiple constraints due to the quality of the hardware parts. The robotic arm will have problems extending and pulling back due to the torque of servos at the middle of the robot. This will limit the range that the robot can extend and its flexibility.

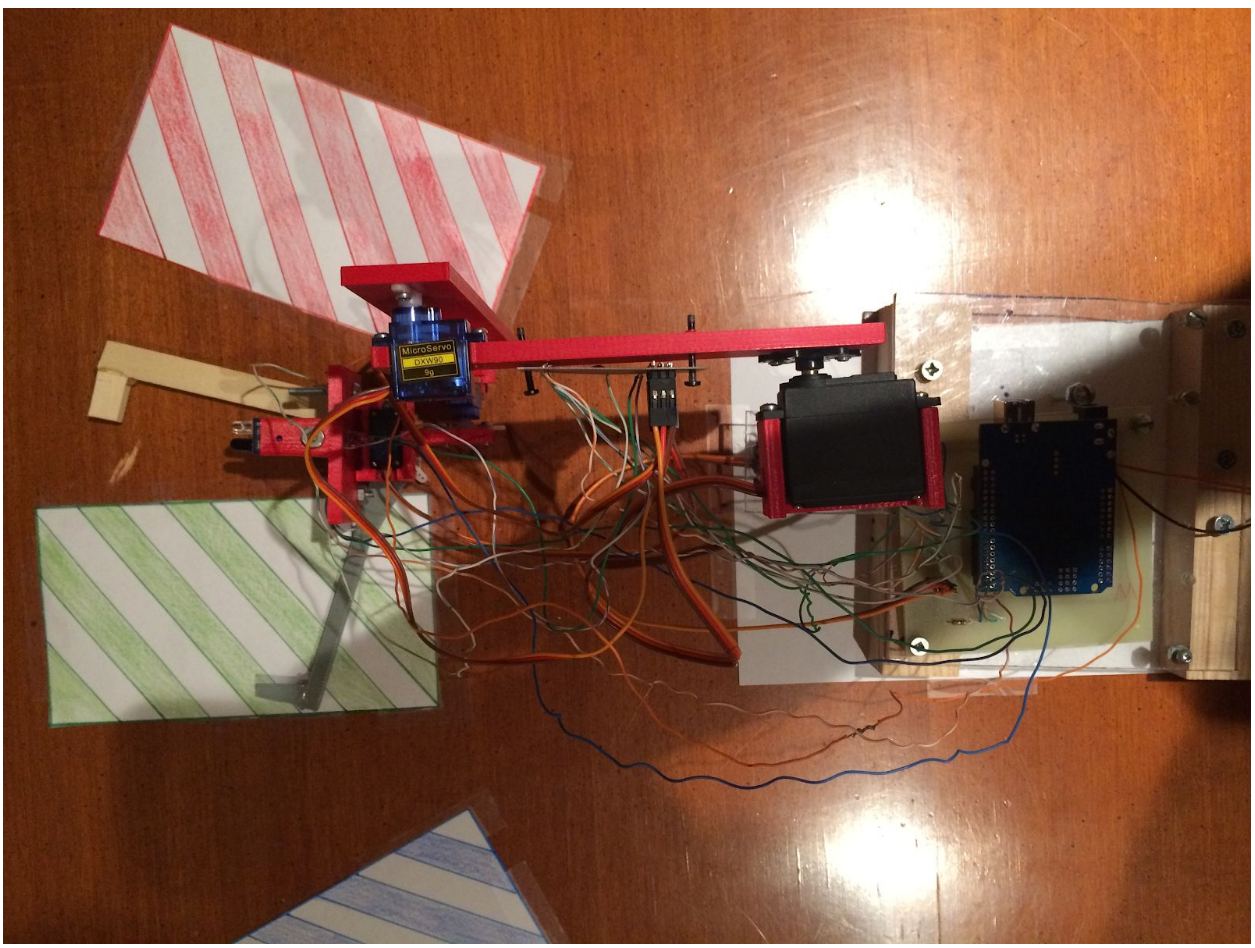
Also, the colour sensor will not function with 100% accuracy because it was made from basic parts and a very simple circuit design was implemented for the colour sensor. Take for example that decent colour sensors cost $10 and mine was made for about 50 cents. Thus, we can’t always expect it to land the barral in the correct zone due to the inconsistency of the colour sensor.

Implementations:

Work Log:

Date	Activity / work completed
Oct. 1- Oct. 10	Choosing what design to print off and make a robot based off of. - Was concluded that a custom designed robot was necessary
Oct 10 - Oct 20	Development of 3D parts for robot -took a few days to learn software, rest of time to develop parts Code was developed: the idea, the concept and the step by step outline of how to robot will complete its job. - Basically, it will scan the load zone, if it sees a barrel, it checks it, and if it has a different colour, it moves it to the desired space. It repeats this process until it does not find a barrel to move after a full rotation around field. - (this is very general but the separated functions have been considered.)
Oct 14-17	Testing for colour and distance (infrared) detection
Oct 15- Oct 25	Development of PCBs for robot -pcb for color detection -pcb for arduino, and the rest of the parts to be connected to directly to it - THE BASE PCB -(first BASE pcb failed) Infrared detectors do not have pcb; their wire will be directly connected to base PCB
Oct. 20- Oct 25	3D parts were printed
Oct 25 - Nov.1	Robot was assembled, without the gripper - Holes were drilled in parts, after being marked by placement of servos and extensions. - Proper screw size and type were found and put into drilled holes to secure parts
Oct 30 - Nov 1	Robot's movement was tested

Nov. 1 - Dec. 12	- Find optimal movement code so that servos can handle weight within their torque level - Finish a gripper, add it to the robot, and test it movement - Attach the additional electronic parts such as the infrared sensor, the color detection pcb, and the pcbs where the color detection will be mounted onto, and the pcb that will extend the wire of the servos to the base pcb - Connect everything onto the base pcb - Connect the arm, base pcb, and batteries onto a surface so that the structure can stand by itself - -test the robot with all parts - Attempt to make the robot complete the GREEN ARM CHALLENGE
Dec 12. - Dec. 28	Robot was tested and troubleshooted until it could complete its tasks without error



Arisen Problems:

As the project continued, more and more unforeseen problems arised, making the development of the robot more difficult. The physical problems of the robot continuously arised due to low value parts and poor design.

While the robot was being built, the parts were separated by large distances, leading to very long wires. These wires were unorganized and ungrouped, making the robot look very messy and making it difficult to keep track of every wire.

Once the robot was completely built, while moving it, it was seen that the wires were too short, and disallowed the robot to fully extend. Thus, the wires were unsoldered and longer wires were resoldered.

While testing movement, it was determined that the primary vertical axis servo does not have enough torque to lift arm when fully extended horizontally. The plan of movement for the robotic arm was altered so it would always remain at the bottom, putting less stress on the servos and making it possible to extend the arm.

While building the robot, the organization of circuitry and wiring makes it harder to assemble robot. Eventually the robot was still built.

The gripper design for the robot could not be deter,omed easily: there was large debate whether to try to find a flexible material that can be bent via string being pulled by servo and retain shape; or, develop a geared part that will be a gripper. It was eventually made that the gripper is just a part attached to a servo and the other arm is a stationary arm attached to the robot. This worked the best as the robot could consistently pick up its barrel and hold onto it and the design was simple, making it optimal.

The biggest problem that arises with hardware was that the power of the board was inadequate to control the servos and electronic parts properly. This problem was attempted to be corrected in many ways such as additional batteries, altered circuit design and even an external power regulator board, but at the end it was unsuccessful, so a power supply was required to give the robot adequate power

Coding Activity:

Over the span of the last month, a huge amount of time was used for programming the robot. With the software development of the robot, there were many software issues and coding problems.

The code's main problems is the efficiency (of code obviously, but more importantly of robot movement). More importantly, the important positions of the robot arm were undetermined, (fully extended, fully reduced, partially reduced), and there was no definite loop yet to make the robot extend and de-extend perfectly. Over the span of the last month, I experimented with the robot to find its best positions where it was strongest and most comfortable. I also shorted the code tremendously by simplifying the base code to the five steps I stated earlier.

Another coding problem problem was making the robot follow all of the commands when we wanted to. For a long time it would just complete the first two functions and stop and not complete the last 3 functions. After testing and experimented, I moved the code of the other functions to the top of the program (in code) and the issue was solved.

Coding the colour sensor was difficult as I had no experience with RGB lights and photoresistors prior to it, so when I implemented the code, there were a lot of errors. With experimentation, I corrected each small error one by one, such as initialization of RGB pins, and their corresponding values, and how to communicate what to the robot should do after it receives the colour.

Critical Parts of Code

Code	Explanation

void loop() {
//move left and check for object
for (int horiPos = 10; horiPos <= 170; horiPos++)
{
hori.write(horiPos);
delay(period);
checkObstacle();
delay(period); }}
	This function makes the robot move from right to left and look to see a barrel.

void checkObstacle() {
//check if object is in front of robot
hasObstacle = digitalRead(obstaclePin);
//if object is seen
if (hasObstacle == LOW) {
delay(50);
getBarrel();
}
	This function makes the robot see if there's an object in front of it. If there is, infrared sensor gets LOW value and getBarrel() function is called

//EXTENSION
for (x = 110; x >= 60; x--)
{
vsPrim.write(x);
vsSec.write(vsSecSpot);
delay(period);
vsSecSpot += 2;
}
vsTer.write(90);
 	
//grab barrel
for (x = 0; x <= 90; x++)
{
grip.write(x);
delay(period);
}
	Code to make arm extend and grab barrel

//DE-EXTENSION
for (x = 60; x <= 110; x++)
{
	Code to make robot pull in after extending (go back to standard position)

vsPrim.write(x);
vsSec.write(vsSecSpot);
delay(period);
vsSecSpot -= 2;
}
vsTer.write(35);	

//if blue
if (((int(colourArray[0])) > (int(colourArray[1]))) && ((int(colourArray[0])) > (int(colourArray[2])))) {
digitalWrite(ledArray[0], LOW);
checkpoint = 50;
}
//if green
else if (((int(colourArray[1])) > (int(colourArray[0]))) && ((int(colourArray[1])) > (int(colourArray[2])))) {
digitalWrite(ledArray[1], LOW);
checkpoint = 100;
}
//if red
else {
digitalWrite(ledArray[2], LOW);
checkpoint = 150;
}
}
	This function compares RGB values and determines what the color of the barrel is. After, it chooses the point at which it will drop the barrel

//go to the location of the colour
if (checkpoint < horiPos) {
for (x = horiPos; x > checkpoint; x--) {
hori.write(x);
delay(period);
}
}
else {
for (x = horiPos; x < checkpoint; x++) {
hori.write(x);
delay(period);
}
}
	This function makes the robot go to the dropping zone

//make arduino appear to stop
cli();
while (true); //An empty loop.
	This code makes the robot run an infinite loop; makes the robot stop since you can't autonomously stop the robot

void checkBalance() {
//check if the balance has been set, if not, set it
if (balanceSet == false) {
setBalance();
}
}
	This function calls the function that initializes the limits of the colour sensor at the beginning of the program

void setBalance() {	This is a very long function that essentially sets what colour is “white” and what colour is “black” for the colour sensor, allowing it to see colours
void checkColour() {	Also a very long function because of mathematics involved. Basically it flashes red, blue, and green of the RGB light and records the amount of light that the photoresistor reads, and it completes this function a few times before averaging out the results and determining a colour

Results and Evaluation

Extent of Achieved Goals:

The robot obviously did not function perfectly as no project is perfect. There were multiple flaws with the robot that were not fixed by the end of the time period.

The robotic gripper never implemented a clean design, limiting how many barrels it could move in one session to one. The stationary arm would just knock over any barrels in its way, thus allowing it to only transfer one barreal going from right to left.

Also, the weakness of the robotic arm limited its functionality as it could only move in specific spots to specific limitations. There are many areas of weakness due to the limited torque on the servos. Here’s a few to name:

1) The arm could not fully extend to its full length as the servos couldn't move it at a certain point in its extension. This resulted in having to place the barrels farther than they could have been placed.
2) The arm could not pull in enough because the servos were too weak, disallowing the robot to grab barrels that were very close to it. Combined with the fact that the robot could not extend far enough to grab barrels, that resulted in having to put the barrels a set distance from the arm.
3) The arm couldn’t extend on its right side due to the design of the robot: the arm sticks out on the right of the robot, due to the nature of servos having their pivot point on their end. The movement could not be corrected from a software point of view because the servos were too weak to extend from over top (when the arm was not touching the floor and was suspended in the air).
4) All of the movement limitations resulted in the robotic arm to have to grab the barrel on its left side, at a set distance from it, which really limited its functionality as the location of the barrel on the field was basically chosen due to its movement limitations
5) The gripper for the arm limited how many barrels it could hold and forced the arm to grad barrels only going from right to left as it would just knock barrels away if it were to move from left to right (the stationary arm on right side of the robot would just keep moving it until it's off the field.

Critical Tests:

Test	Date	Result
movement	Nov.15- Dec 15	-moving arm left to right success -moving primar axis arm up and down success -moving secondary axis arm unsuccessful -moving tertiary axis arm success -moving gripper arm success -extending and pulling in Unsuccessful: was concluded that robot could only do partial extension, so that's what we have to work with -extension of left side of robot successful -extension on right side unsuccessful -extension in middle successful -concluded that robot can move, but it can only grab barrel from left side to middle, an it could only do at a specific range. -multiple servos had their gears grinding together when exposed to too much weight (the micro servos on extension), thus resulting in the servos to make a large 'grind' sound when extending. -tertiary arm axis could not handle weight progressively as the robot extended, so it had to be kept in a constant position and moved separately from the other servos.
Infrared sensor	Nov.20-22	-distance that barral could be seen was tested. -was concluded that the robot could recognize when a barral was in front of it from the maximum required distance, making test a success
Colour sensor	Nov.24-30	-tested for colours separately. Code was incorrect initially, resulting in program to say it was reading the wrong colour, when it actually was reading the correct colour. -after a few adjustments to code, robot could see colours correctly, with a little bit of inconsistency due to quality of parts. -concluded to be a success

Overall function	Dec.10-30	-attempted to combine all other functions into one to have robot complete its desired task. -big problem with power to the circuit: the parts were functioning improperly because of the amount of power that was supplied to them. After addition of multiple batteries, circuit redesign and addition of eternal power regulator board, p=parts still functioned improperly. This problem was eventually solved with the use of a power supply. -after power supply issue was solved, after some experimenting, and code adjustments, the robot could successfully find a barral, grab it, sense its colour, and transfer it to its proper zone. -was concluded at that point that robot was complete as I didn't want to create a new problem with more code adjustments, or a break in the design

Final Result:

At the final result of my project, I can say that I am satisfied with what I have made. I had spent too many hours on this project learning many valuable lessons on physical build design, circuit design, and software design. I am confident that my project is an overall success because the robot could complete what is was originally required to complete. Although it did not complete it to its fullest potential, it still completed the task and due to its immense level of difficulty, I can say that I did accomplish a big goal by completing it.

Future Work

Build Design:

Looking at the complete version of my robot, there are many spots for improvement when it comes to the design of the robot.

The length of the pivot arms could be readjusted to a different length so that the arm could reach barrels that are point blank range to it. The readjustment of the length of the arms could also help the robot extend farther, and help the robot move more smoothly.

The choosing of parts that control the movement of the robots should be upgraded to have more torque so that they could handle the weight of the robot and move it smoothly. Also improved servos will allow the robot to extend fully.

The electronic parts for sensing the colour of the barrel could be upgraded or just replaced by a complete colour sensor circuit so that the robot could consistently sense the right colour of the barrels.

The design of the 3D parts could be improved so that the arm of the robot will be centered in the robots radius. This is very important as it would allow the robot to extend on the right side, something that my robot could not do.

The wiring of the robot could be cleaned up and done more smartly. The wires could have been grouped and tucked inside of a shell to make the robot look a lot cleaner. 2 wires were soldered together to extend it and exposed, so that could have been covered to limit the chance of short circuits, as well as the exposure of the pins of the infrared sensor, which can limit the chance of short circuits even more.

The gripper is very important as it determines if the barrel can move a barral. My gripper was handmade using wood and glue, hinting that its design was poor. It could be improved with the implementation of a pulley or gear for the gripper, which would allow it to navigate between barrels and grab them going left to right.

Circuit design:

There are many spots to improve when it comes to circuit design.

The power extension board could have been completely eliminated if the wiring is done well on the robot, which would help out with circuitry as it limits the chance of having a broken circuit.

The power regulator board could have been worked on more so that it could actually work with the robot: we confirmed that it can convert 9V to 5V, but the robot still did not function with it, so it was removed to make things easier. If this board were improved so it works, we could eliminate the use of a power supply, making the robot a lot more mobile.

The main base circuit board was much larger than it had to be, and even though not all ports of the arduino were used, it was a bad decision to not include them in the circuit a they could have been used later on for additional electronic parts. Also, the use of solo SIPs caused them to break off the board often, making a lot more work for me as I had to continuously resolder them. This could be improved by just putting a SIP for every pin of the arduino as it may come handy in the future, and it makes the mount stronger for the arduino.

Software Design:

There are multiple specific spots of the code of the robot that could be improved to make the robot function better.

After the robot senses the colour of the barrel, instead of going to its desired location from where it senses the barrel, it goes all the way to its initial position and then the desired landing zone. It jolts and puts a lot of stress on the servos, and this problem could be solved with readjustments in the code to remember its position and use it to find the zone more efficiently. I tried this but it did not work, so I left it how it was as I didn't want to harm its performance even more.

When the robot extends the tertiary arm axis does not move, and after all the other parts extend, it jolts to its extended position. This movement sometimes knocks over the barrel, puts a lot of stress on the servo, and makes the movement of the robot look jolty. I tried to incorporate the movement of the tertiary arm axis with the other servos, but it was unsuccessful, so I left it how it was with the jolting movement.

The overall code could be shortened and optimized so that it would be more efficient for the robot. With less storage usage on the arduino, it will lead to a higher chance of having a successful test run as the arduino will be less prone to failing.

Unrealized Goals:

There are many things I could have done to the robot with its design to make it possible perform better. In terms of software, I could only improve it, but I couldn't redesign them so, there are no additional unrealized goals with those things. As for the build design, there are many different ways that I could have developed an arm that could have completed its task.

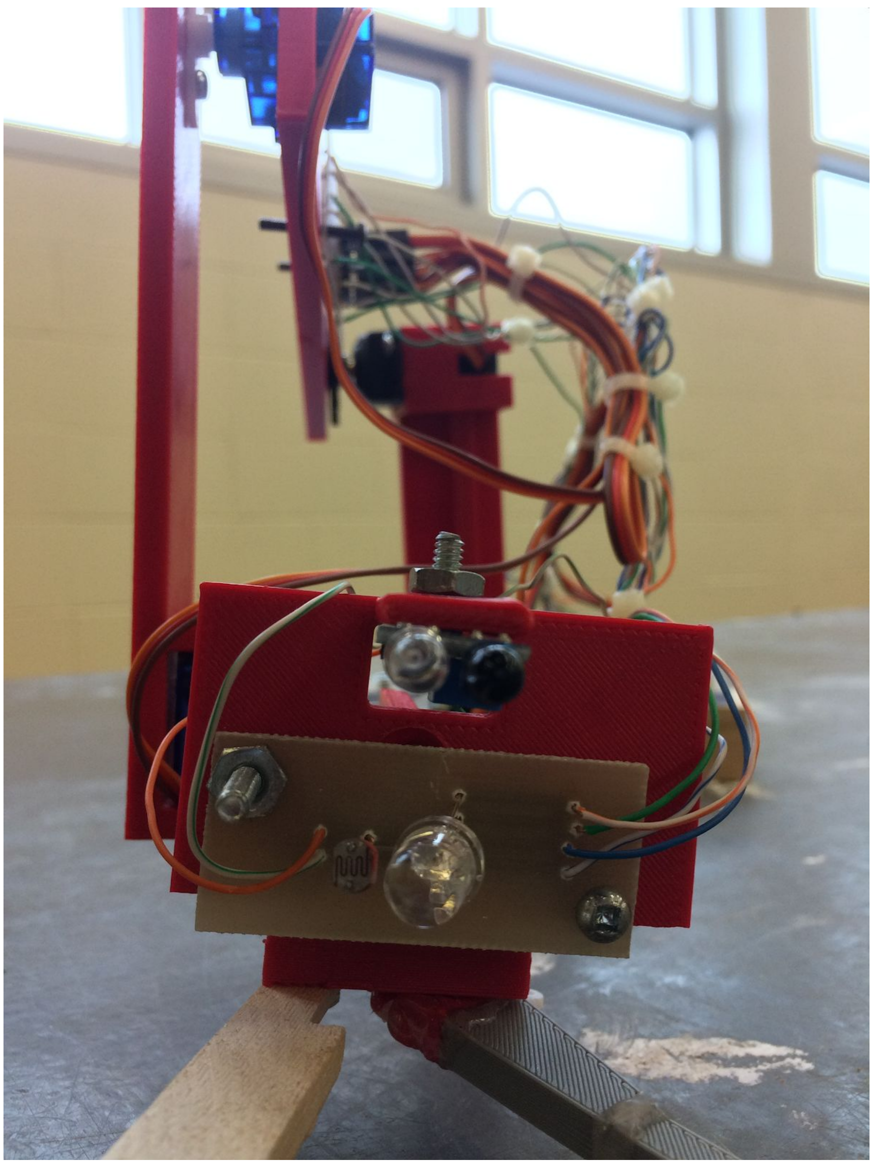
One design inspired me was to have a vehicle attached to a base, that followed a straight path, thus acting as an arm still. This could be advantageous as the vehicle that rolls on the floow will have a smooth movement forward, allowing it to complete its task easily.

Another design would have a 2-axis moving arm attached to a pole that escalates up and down as the robotic arm. The two axis arm would have one pivot moving up and down, and another pivot for the wrist of the gripper. This arm would be attached to a pole which would allow it to move up and down. This design would be very beneficial for the robot because its loess pivots for the robot, allowing it to be stronger and easier to control, as well the design is stronger with a straight pole holding the arm. Although with controlling the movement of the robot, I was considering putting motor controlled wheels and moving the robot on the wheels as it would put less stress on the arm if it doesn't directly connect to the arm, it it would've been beneficial for the robot as it could have been able to move and be mobile. If I could’ve restarted this project, I would’ve definitely followed with this idea because I feel that I had a lot more potential than all of my other ideas.

Conclusion:

Statement:

To conclude, my robotic arm, the Green Arm, is an arm controlled by primarily servos for movement, with the addition of a colour sensor and infrared sensor to allow the robot to see objects, with all electronic parts connected to an arduino to control the robot's functions. My robot, overall, was capable of finding a barrel, grabbing it, determining its colour, and placing it in its corresponding colour zone.



Lessons Learned:

Overall, there was a lot to learn from creating my robotic arm.

I learned that the physical build of a robot comes to be very important as it will determine what the robot is capable of. My robot lacked in the build design, which really limited its functionality, despite my ability to code being very high. Thus, you must pay close attention to every detail when building and consider what will happen AFTER you make the part. A good question to ask from now on when building is: “will this part work with…?” As well, when I’m in the process of designing a robot, I have learned that it is ok to scrap your old ideas. There were multiple times in my project where I had to scrap a part, redesign it, and implement it again into my robot.

I learned that when it comes to the development of circuitry, the most important thing to consider is the flow of electricity through the parts. I learned to view the building of circuits in this view as it will allow you to consider the design of the board, what parts will go through each path, and how much power each part is getting.

I learned that when I’m designing software, I have to pay close attention to the hardware of the robot, as that will limit what iI can do with the software. When I’m writing code for my robot, I have to keep close attention to the path of code: I need to consider what the robot will do in each function and how that will lead off into the next function. A big problem in my project was that whenever my robot completed a function, it would do something else very random, because in my next function I did not consider the robots previous positions. As well, I learned that you can make up for flaws in design to a small degree if you code in a proper manner. So I could nullify some flaws in my design because of how I coded my robot to move.

Also, outside of the designing process, I learned that it wouldn’t have been so bad to pick a simple project to start with. It would have taken a lot of pressure off me because it is easier to build, and once I will have had a build robot, I could have just improved it from there on, and eventually it would have been better than my robotic arm.

Aside from the project, I learned how to use many more tools, which is valuable for creating projects in the future. I learned how to use how to use a power supply with robotics to test their function. As well, I learned many more options on the multimeter such as the resistance option and how I can apply that to my circuit.

Potential and Future Capability:

My robot was just a prototype and a first time build for me. Now that I have the base concept down, in the future I could develop it better (as explained above). But what I am more concerned about is the potential of what robotic arms can do. Even on the ground, it can do so much, but how about if I change where the robot will go? Say for example, how about if I mount the robotic arm to a wall?

My robot can be mounted onto a wall, and can serve purposes on the wall as well, as it has enough power to support its own weight and additional weight from other objects. For example, I can use an upgraded version of my robot to serve the purpose of a robotic coat hanger. It could create a hook for me to place the coat, and then move and transfer it to a nearby simple coat hook. As well, since I plan to build a mini quadcopter in the future, my arm could hold the robotic quadcopter, and transfer it to a platform on the wall, or take it from the platform on the wall, or the robotic arm could load the quad copter with an object to transfer across the room. As I said, this basis of a cheap costing robotic arm has a lot of potential for other projects as robots can communicate with each other. But there is still room for the robot to accomplish more.

This robot can be part of a larger robot, and with that being said, it’s purpose of moving a single object can be combined with movement, and additional tools to allow it to navigate through many realistic scenarios. For example, multiple robotic arms can be mounted into a machine in a factory, and they can work together to sort out products on a mass scale. As well, the arm can be mounted onto a robotic quadcopter, and find objects that the quadcopter is sent to find, such as finding a home phone in the house. The arm can also, with enough development, be augmented onto a robotic person, and provide the arm for the robotic human. Whatever the scenario may be, this robotic arm can be added to it to enhance it.

My robotic arm can provide basis for a revolutionary advancement in technology and I plan to use it to my advantage to enhance other projects, with the ultimate purpose of enhancing our lives. All of these scenarios that the arm is added to is just an idea of what it can do. Any scenario of sorting, or moving, creates a possibility to use this robot to make it easier. Making simple household tasks saves stress for those with no time, creates a lot more possibilities for people without vision as it can act as the eyes and hands for them, and can be part of larger machines to enhance industry. The potential of this arm is determined by what the users of the arm want it to be. For me, I just want the robot to sort for now, but I will add it to a larger project in time, because I know it is capable of much more.

Overall Final Thoughts:

To conclude, I believe that this robot was a great learning experience for me as I learned many valuable lessons from it and improved my engineering ability. I will continue with creating small projects like this as a side hobby in university as I believe it is very beneficial to my learning experience and will help me add to my portfolio to look like the best match for a job. I have learned to see the engineering process in a new way now and I am satisfied with this new view. While developing this project, I went through a lot of stress and considered quitting multiple times, but with assistance from some friends and yourself, the teacher, had helped me continue as I kept finding new hope for the project, and was focused again after getting help each time. This course was well planned out this year and I look forward to seeing what your class will accomplish next year.

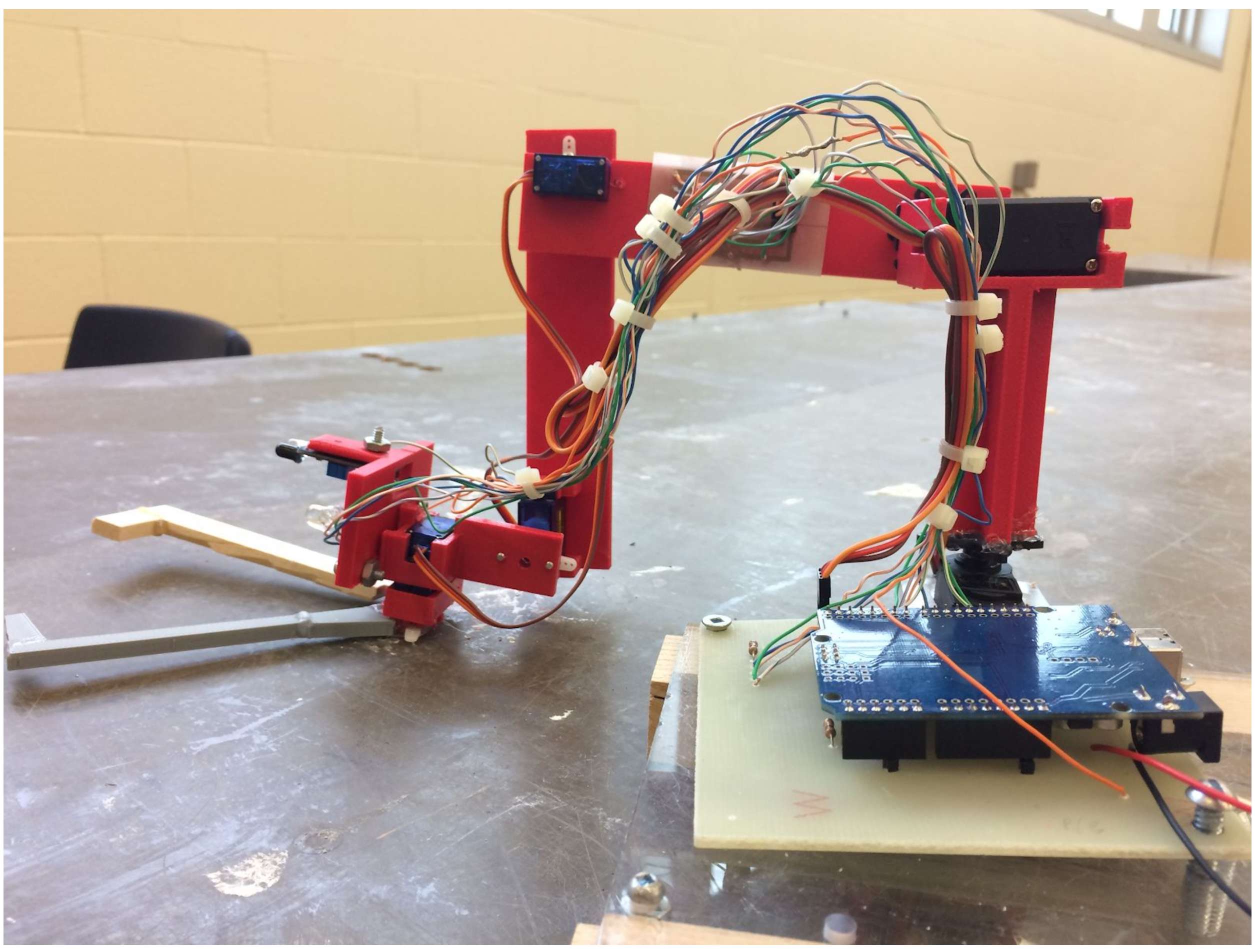
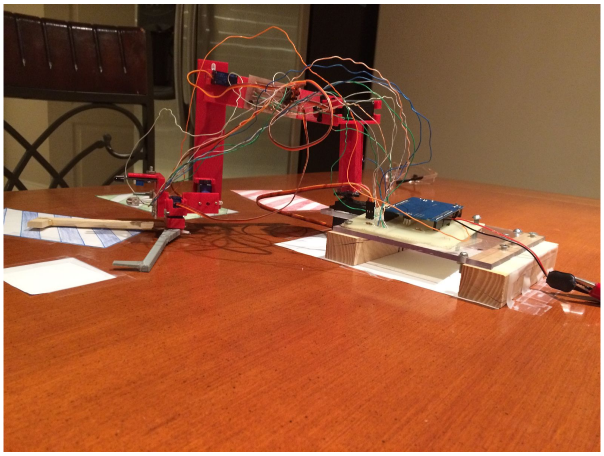
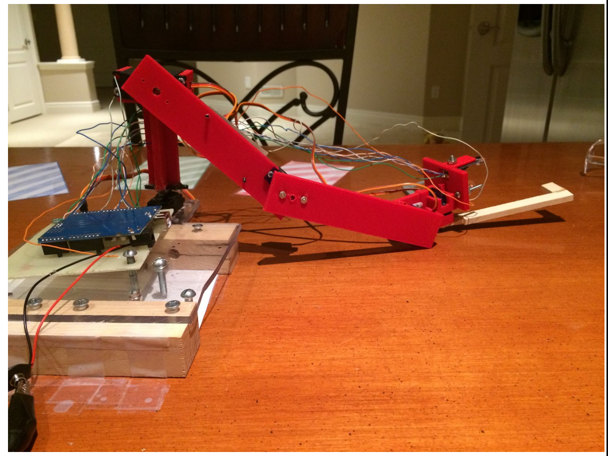
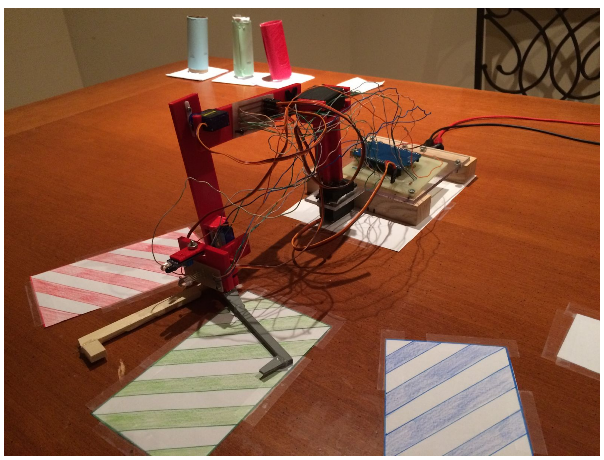
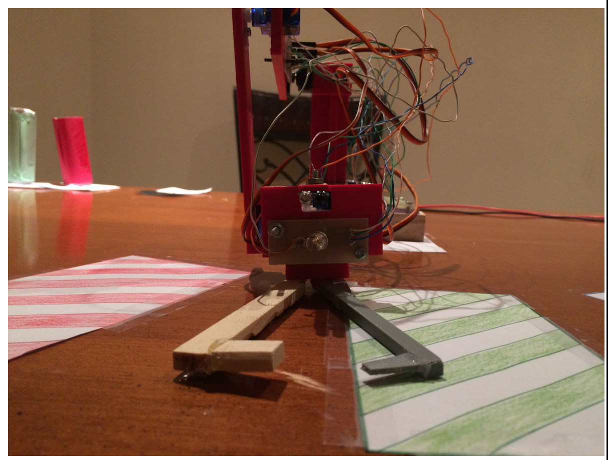
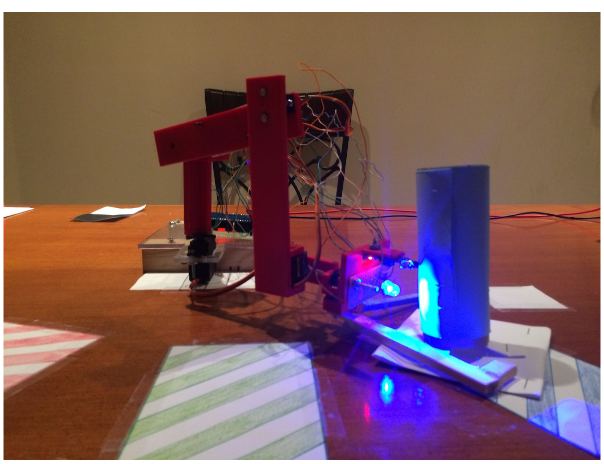
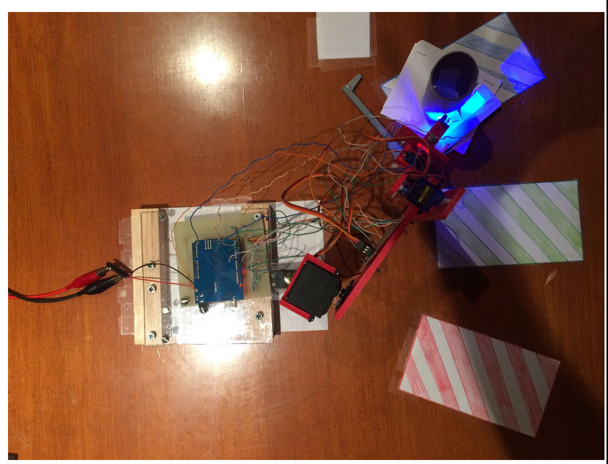
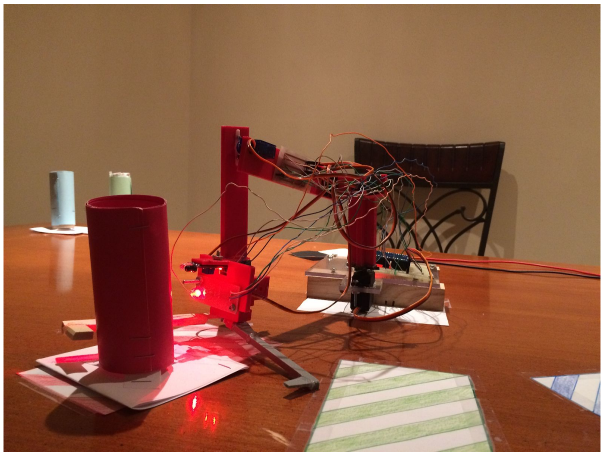
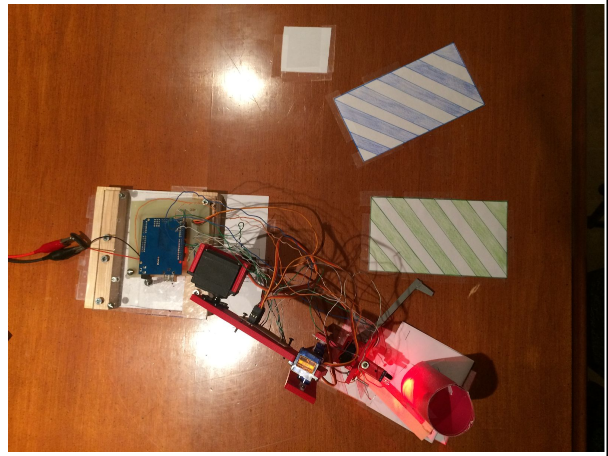
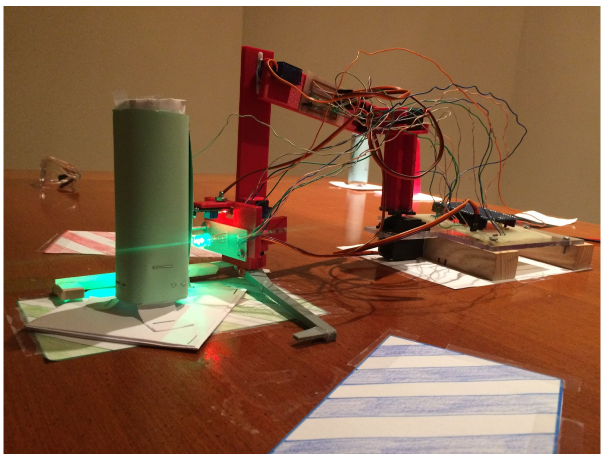


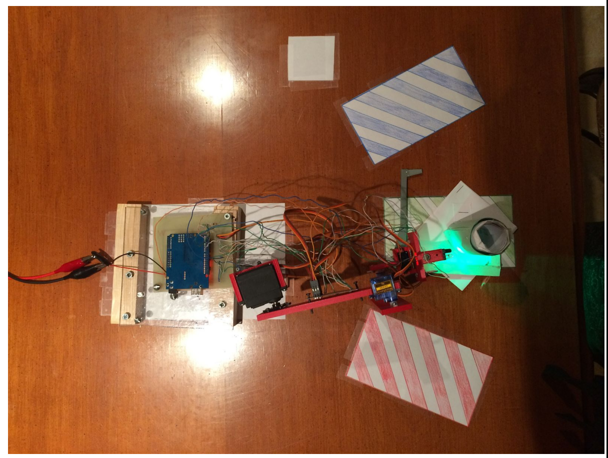
Photo Gallery

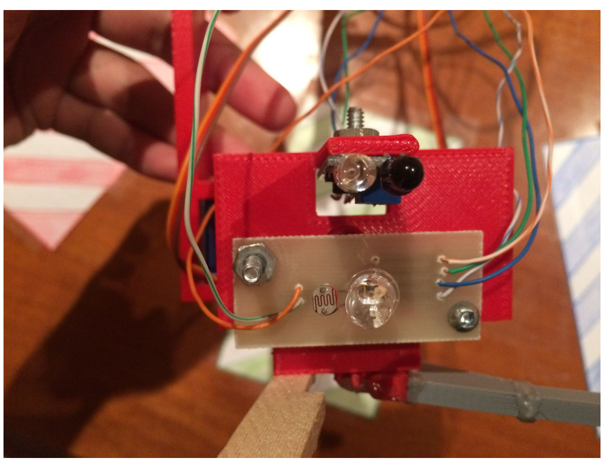
	
	
	

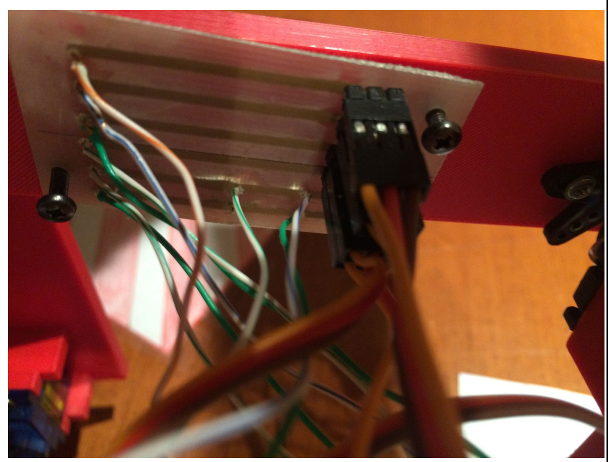


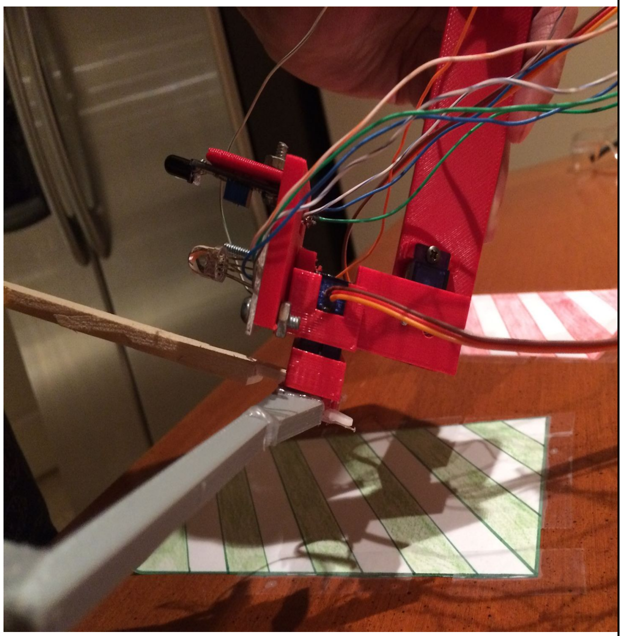


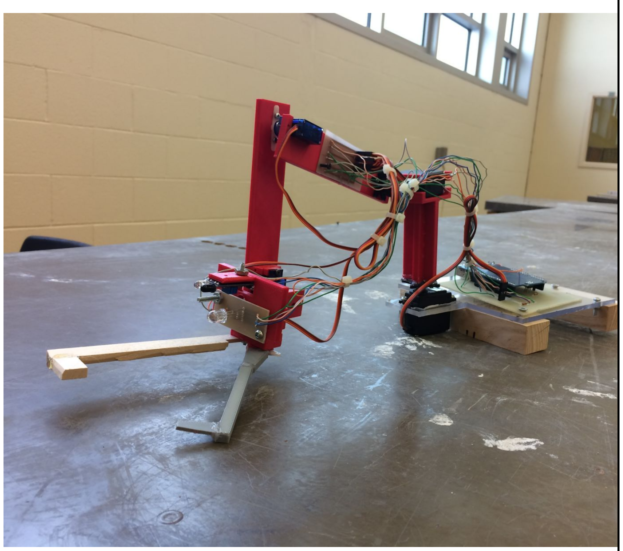


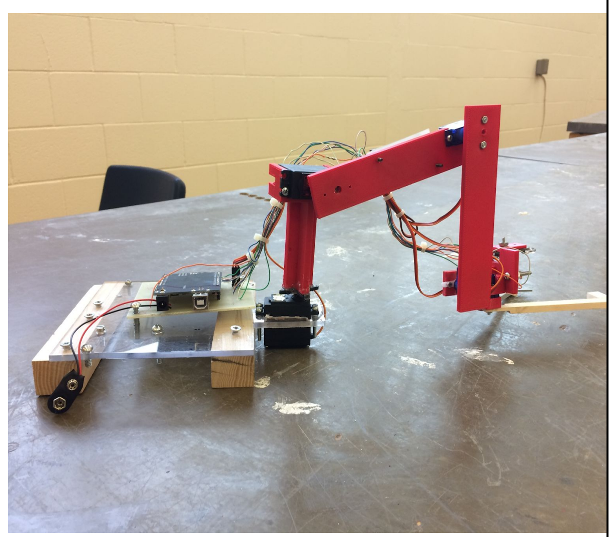


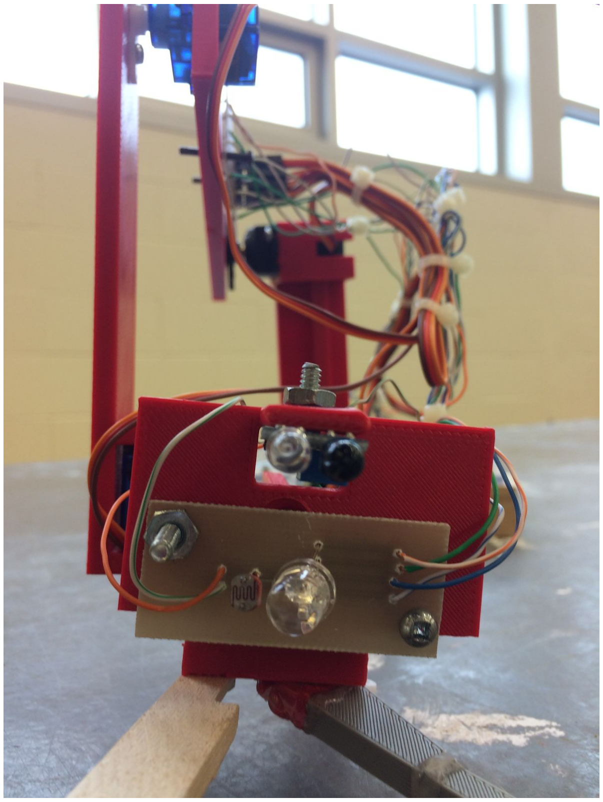


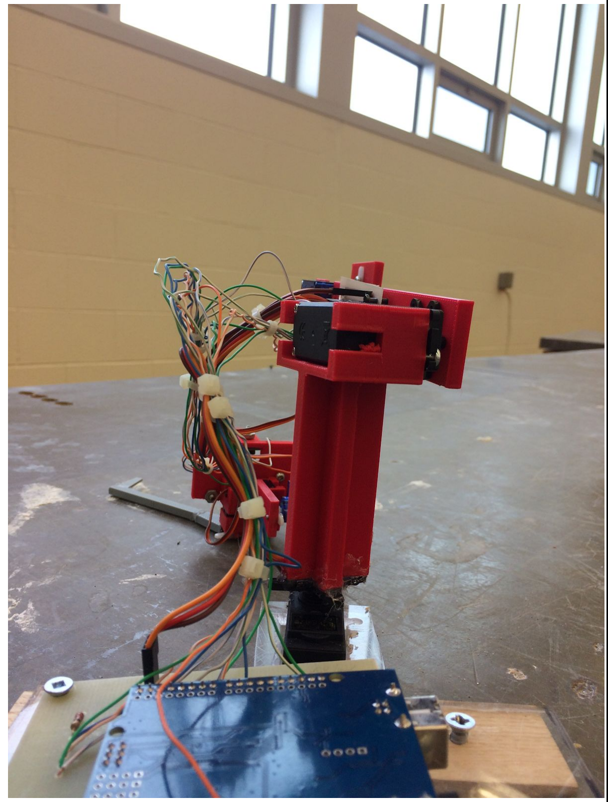


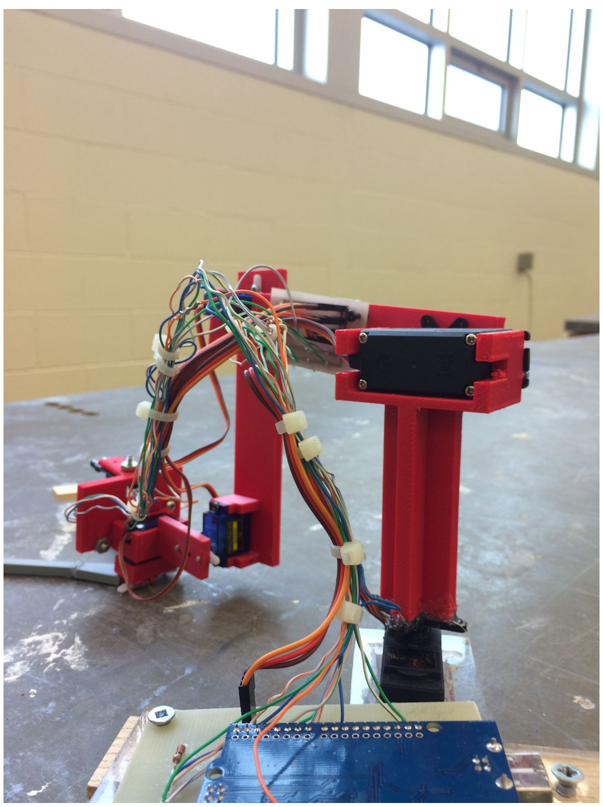


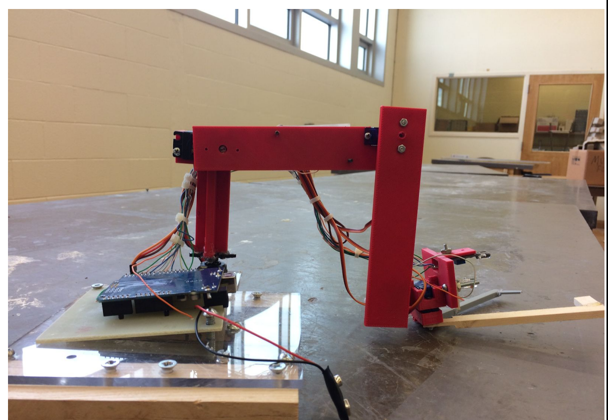












Video Gallery

All Video Files can be found in the “Robot Moving Videos” in the Green Arm File.