TASK:

Design a robot that implements two functions, attack and defend. The robot should be able to navigate through an obstacle course. When in attack mode, the robot should be able to go to a predetermined location where the balls are stored, pick up the ball and get in a position good enough to shoot the ball on target (goal) and attempt to score without entering the defender zone. When in defense mode, the robot should be able to find the goal and set itself in a position to block the ball from entering the goal."

HARDWARE DOCUMENT

DPM TEAM11

Author- Intesarul Khan

DOCUMENT VERSION- 2.0

April 2016

Table of Contents

Objective:

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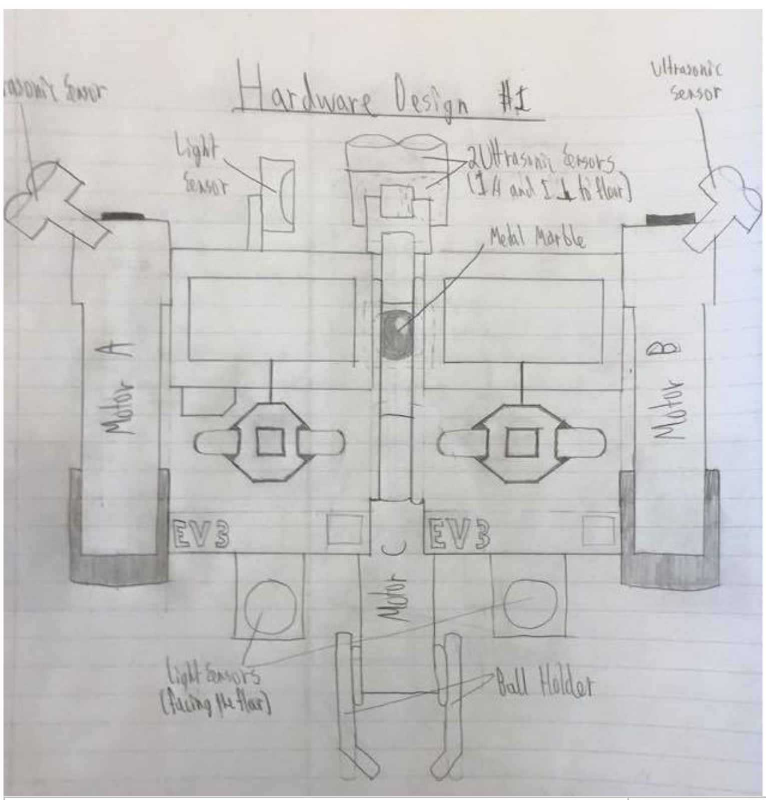
Preliminary design plans:

Initially we thought of two alternative ideas to build the robot for the task. The two design plans are discussed below:

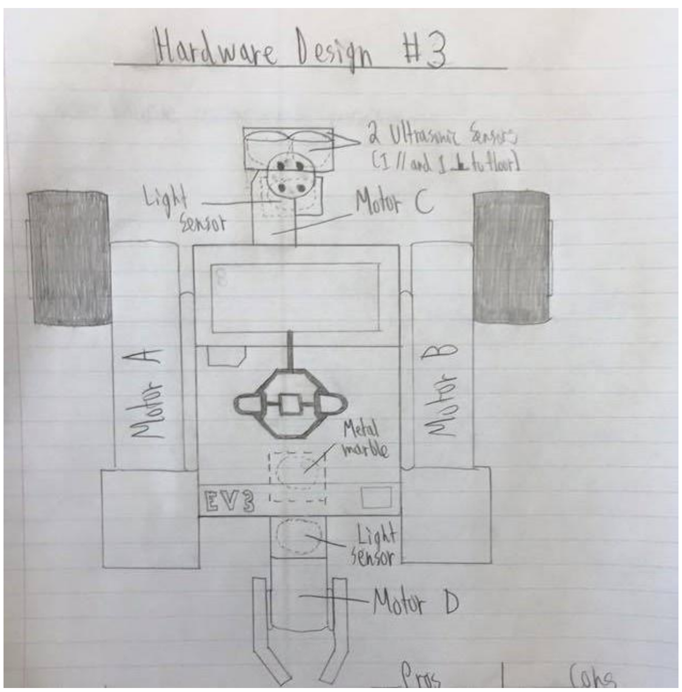
<u>Design 1:</u> An autonomous robot with a catapult mounted at the back, using one motors for scooping and shooting mechanism.



Hardware required	Purpose of hardware components
2 EV3 Bricks	To connect all the motors and sensors.

3 Light Sensors	One sensor to be used in the front as a color sensor to detect coloured balls and the two light sensors at the back to be used for light sensor correction.
4 Ultrasonic Sensor	Two Ultrasonic sensor were to be placed in the front for obstacle avoidance and the two at corners for wall following
3 Motors	Two motors to rotate the left and right wheels and the last motor was to be used for the catapult mechanism
1 Metal Marble	Used for turning/rotation of the robot

Design 2: An autonomous robot with a catapult mounted at the back, using two motors for scooping and shooting mechanism.



Hardware required	Purpose of hardware components
1 EV3 Bricks	To connect all the motors and sensors.

3 Light Sensors	One sensor to be used in the front as a color sensor to detect coloured balls and the two light sensors at the back to be used for localization.
1 Ultrasonic Sensor	Placed on the front for obstacle avoidance
4 Motors	Two motors to rotate the left and right wheels and two motors for the catapult mechanism
1 Metal Marble	Used for turning/rotation of the robot

WEEK 1: Version 1.0 of Robot

14th March, 2015
Author: Intesarul Khan (Team 11)

Overview

According to our Design Plan #1 our plan was to implement two EV3 Bricks for the availability of more ports. However, we realized that using two bricks would be difficult to implement as making them interact with each other is a difficult and time-consuming process. Secondly, we would not be using more than 3 sensors in our design and since one brick can fit up to 4 sensors at a time, we decided to implement one EV3 brick. Furthermore, we decided to make a "claw" at the back of our robot, instead of the front, so that it does not interfere with the sensors which are all placed in the front, as it navigates through the field. Hence, we built the robot according to our Design Plan #2.

Reasons for choosing the design

Initially we thought of using two EV3 bricks for the availability of more ports. However, we concluded to use one instead to avoid the hassle of making them communicate with each other and to keep the robot compact. We initially wanted to use a rotating ultrasonic sensor for efficient obstacle avoidance and wall following however since we were limited to the number of motors we are using we decided to use two motors for the catapult motion and the other two for the movement of the robot. Our goal was to keep the robot as simplistic as possible.

Drawbacks for the design

- The connections between the brick and the other hardware components led to the wires being disorganized. This might hamper the functionality of the motors.
- Since we will be using only one brick we would be having there will be problem with battery. We are yet not sure how much power the battery can supply and for how long for which it needs to be tested.

- Catapult power may be also limited as we will be using one brick power.
- Since we will be using one ultrasonic sensor in front of the robot for obstacle avoidance we cannot implement wall following.

Prototype

This model is not the final version of the robot. The objective of this week was to develop the base and the grab mechanism of the robot and see how it can be put together.

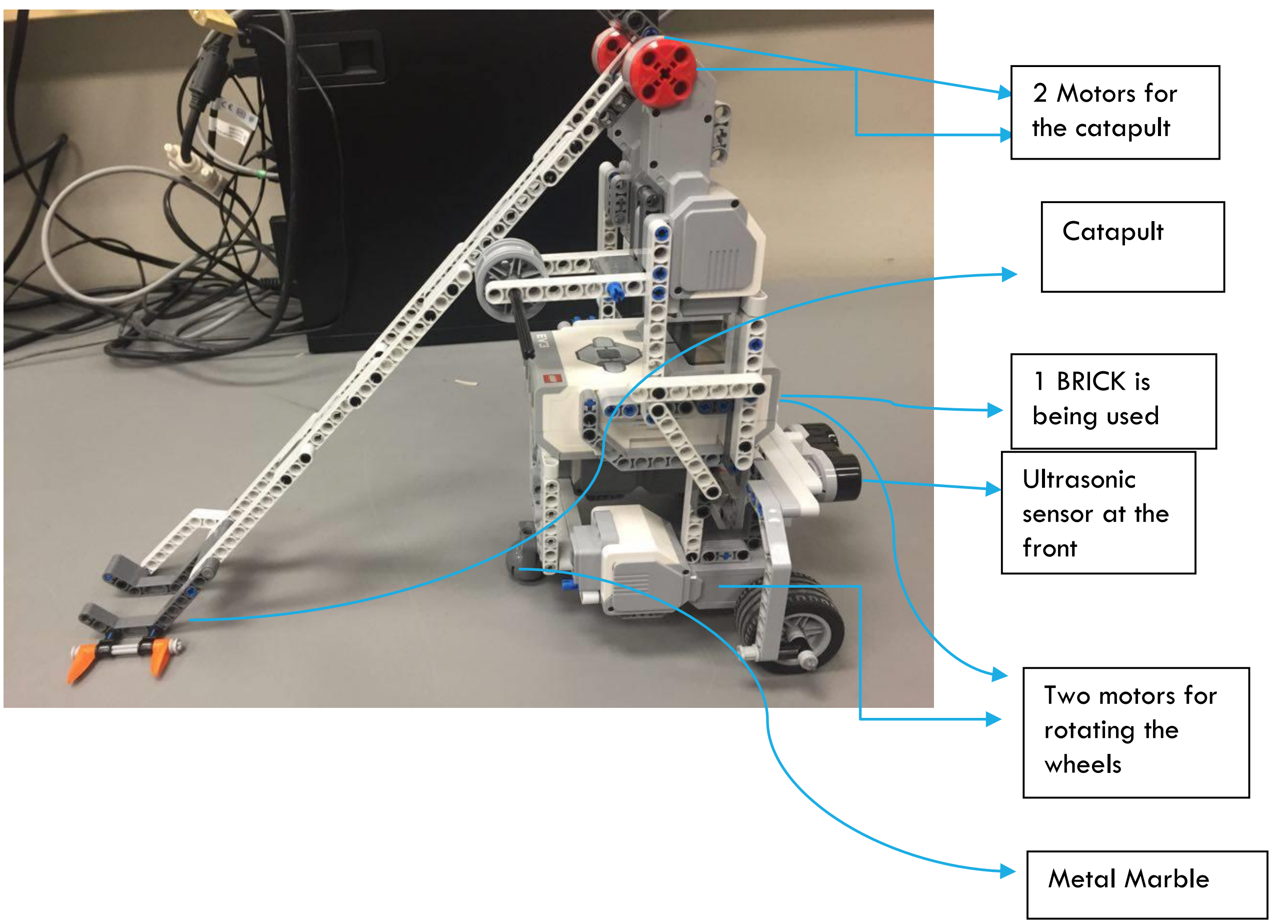
WEEK 2 & WEEK 3: Version 1.1 of Robot

15 March 2016
Author: Intesarul Khan (Team 11)

Overview

Although we had a preliminary plan for our robot, the robot needed major adjustments and modifications. We have attached a picture below of the design we made:

Side view of our preliminary mechanical design

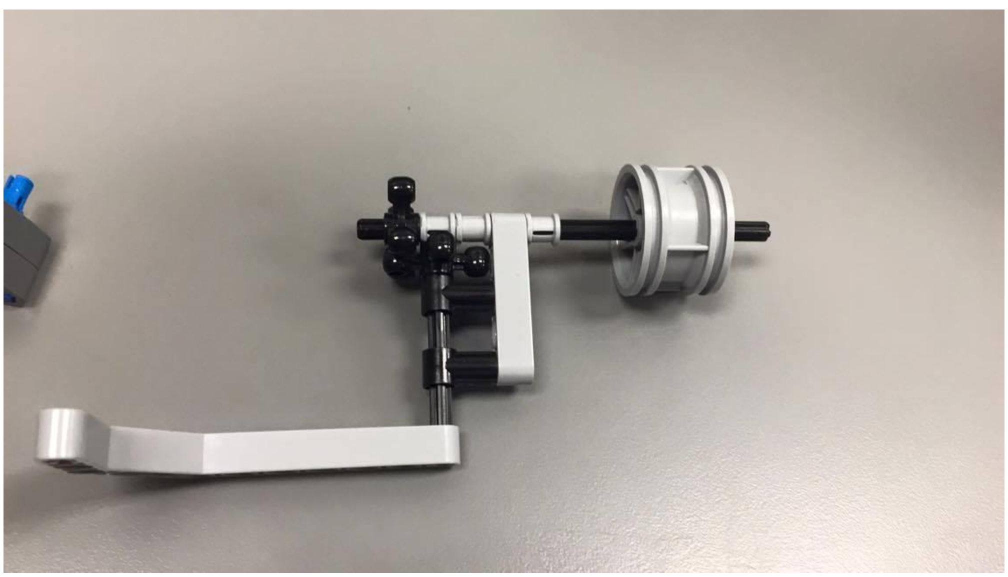


Improvements made to the design

A rough mechanical arm was integrated into the design for loading the ball onto the catapult and the height of the catapult was adjusted addressing the limitation of the robot. We also placed the light sensor on the right side of the robot which would make it easier for ball detection. The two light sensors at the back will be used for odometer correction and localization. The Ultrasonic sensor was placed in the front which will be used for navigation.

How does the catapult of the robot work?

The difficulty we faced when designing the robot was how we were going to load the ball on the catapult. We initially tried to implement a scooping mechanism however we did not have the correct parts required to build the design. Hence we came up with another way of loading the ball onto the catapult. Instead of trying to scope the ball onto it we decided to create a mechanism that kicks the ball onto the catapult which is placed on the side of the catapult. The way this works is as the catapult is lowered it the motor are connected in chains and gears. So as it is lowered the kicking mechanism will kick the ball onto the catapult. The problem we might face with this is that it might be difficult to time descend with the kick. The picture of the kicking mechanism is given below. This will be attached beside the catapult

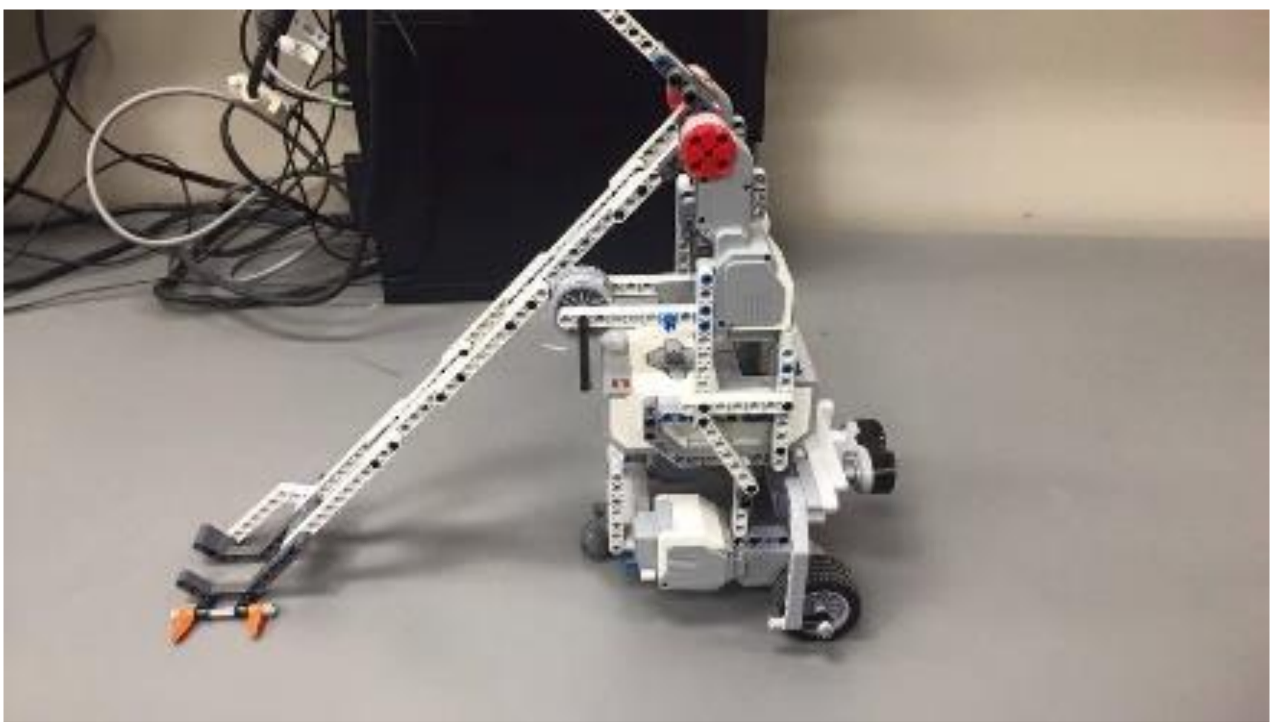


Improvements

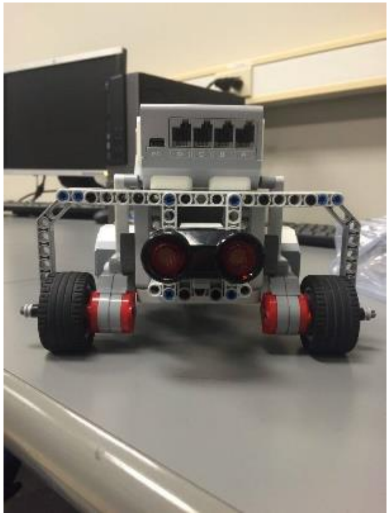
- We are yet to implement the throwing mechanism onto the robot and test the entire robot. There might be huge problem with timing for which we might have make further adjustments to the robots
- We need to correct the sensors and integrate it onto the robot and make sure it functions smoothly with the mechanical design
- Build a stronger catapult to refrain from dropping the ball.
- Make a more rigid design by ensuring all the components are connected to the brick properly.
- The connections between the brick and the other hardware components led to the wires being disorganized. This might hamper the functionality of the motors. Connecting wires should be taped to prevent them from getting tangled.

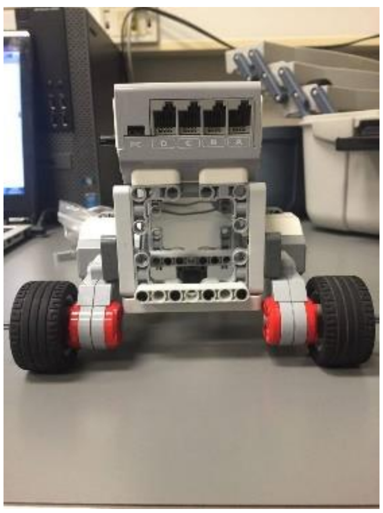
Prototype

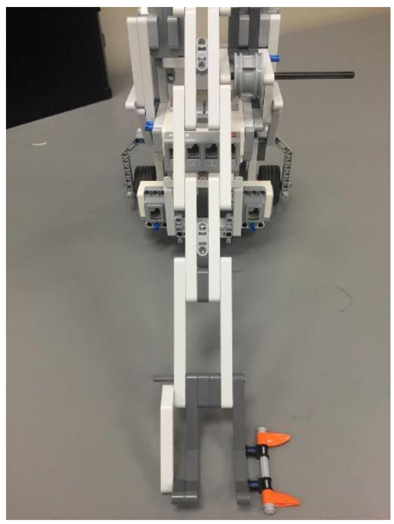
This model is not the final version of the robot. The objective of this week was to develop the base, the lifting and the throwing mechanism of the robot and see how it can be put together. We also need to make further improvements to our robot to see how well it can work with the software. We are to test a lot of things.



More pictures of our mechanical design (version 1.1)







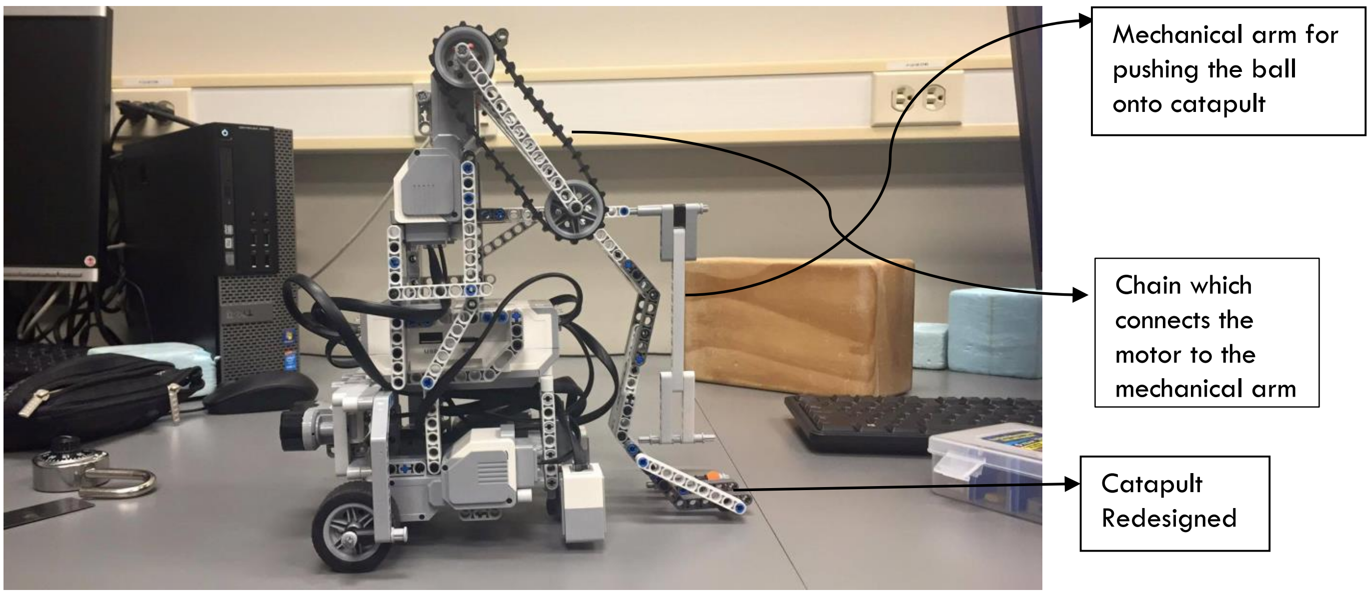
WEEK 4: Version 1.2 of Robot

15 March 2016
Author: Intesarul Khan (Team 11)

Overview

Although we have built our robot, the robot needed major adjustments and modifications as the wide design of the robot makes it difficult to navigate the map with no obstructions. Modifications were made to the mechanical design to make it execute its objectives more smoothly. We changed the entire mechanical arm which uses the same motor as the catapult to load the ball onto it. We have also tried to address to all the limitations that were in the robot built last week and made changes accordingly.

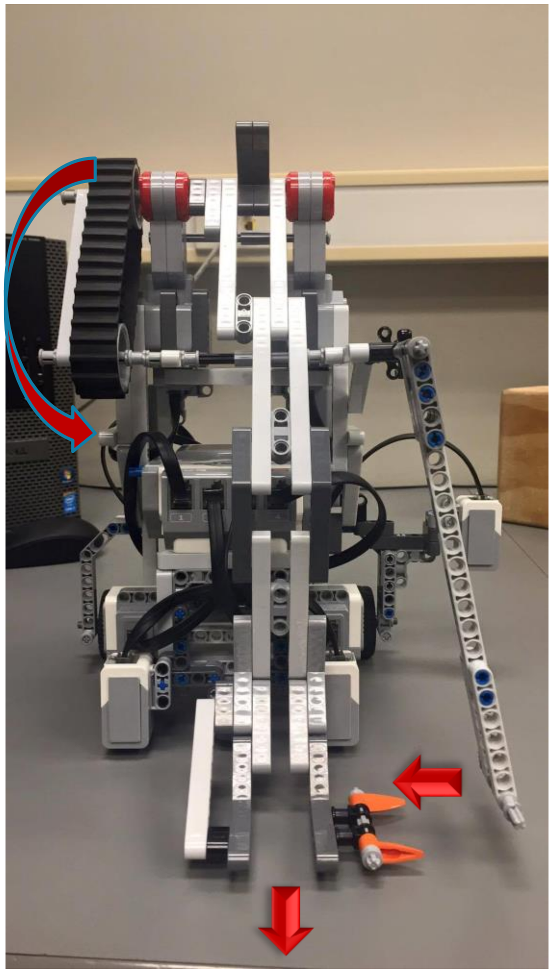
Modifications made to the robot



In our previous design the robot was incomplete. The mechanical arm that is used to push the ball onto the catapult was not adjusted properly and we were planning of using two chains for connecting the mechanical arm to the motor of the catapult. The two light sensors at the back was yet to be placed in position and the catapult design was changed for better release of the ball. In our previous design the catapult was too unstable and not rigid enough for creating a good projectile. The two light sensors at the back for were added for correction. One geared belt was removed and the mechanism that pushes the ball in the catapult was adjusted based on the dimensions of the ball rack The catapult (excluding the two motors) was shifted two blocks to the right (where the light sensor and the balls are). Lastly a bar was added that prevents the catapult from going over to the front side of the robot.

How the catapult and the mechanical arm of the robot works

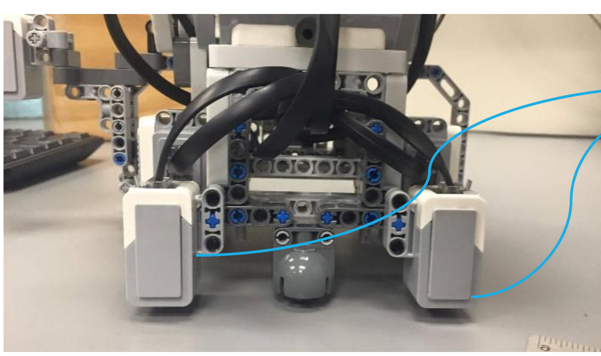
The robot uses one motor to complete the task of loading and shooting the balls with the help of its distinctive constructions of beams, axles and gears. The working procedure of the mechanical arm and the catapult is discussed below.



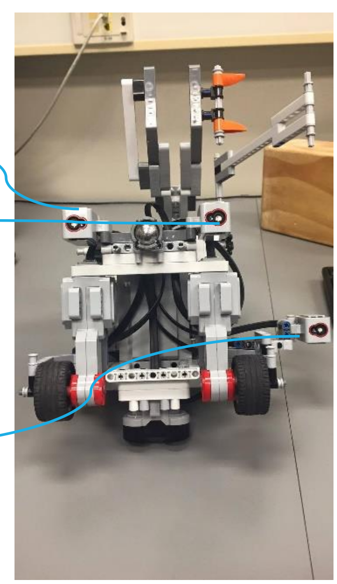
OPERATION OF THE MECHANICAL DESIGN

We made a fairly simple design for our robot. As the catapult descends the mechanical arm moves in the direction shown pushing the ball onto the elevated platform of the catapult. The mechanical chain connects the two mechanical parts together as shown allowing only one motor to control both the motion of the catapult and the mechanical arm. As the motor spins the chain rotates in the direction shown causing the following movements as shown in the diagram. We chose this design based on its simplicity and due to its effective use of the motor. The other motor will be used to generate the extra power to throw the ball at the distance required over the defense line.

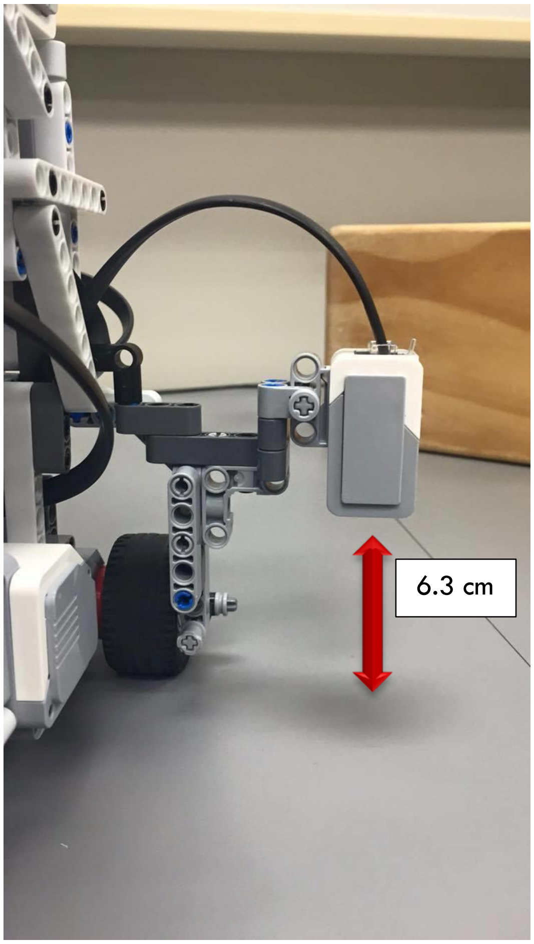
Light Sensors are integrated onto the design



Light sensors being used for odometer correction, navigation and localization



Light sensor used for Ball detection



The height of the light sensor (used for ball detection) was adjusted based on the dimensions of the rack. This would allow better detection of the ball as the ball will fall vertically below the light sensor which will enable much smoother operation. We decided to place the light sensor at the side so that it can detect the ball as it moves. This in turn enabled us to speed up the process as faster maneuvers could be made and we did not have to reposition the robot just to detect the ball.

Further details

We have made changes to our robot but we have used the same number of sensors and motors as planned previously. We did not implement the taut tracks because we realized that the tracks created a problem in terms of navigation as it would slow the robot and obstruct the course with rotations. So we stuck to the base design with wheels. We have also put the ultrasonic sensor in the middle for localization to work properly and have made all the changes that were mentioned in the improvements before.

Prototype

This model is our final design but we will be making changes to it based on the software requirements if needed.

More pictures of our current mechanical design (version 1.2)

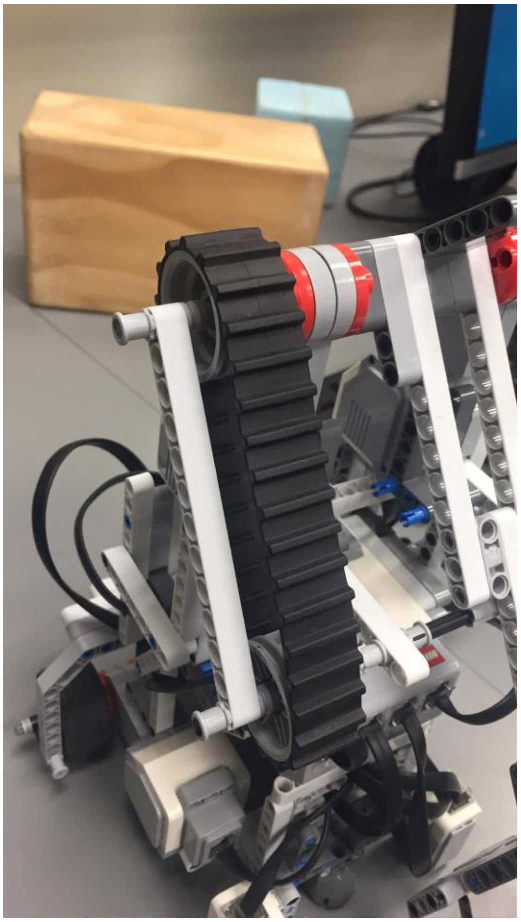


Figure 3 Mechanical Chain used for joining the arm and catapult

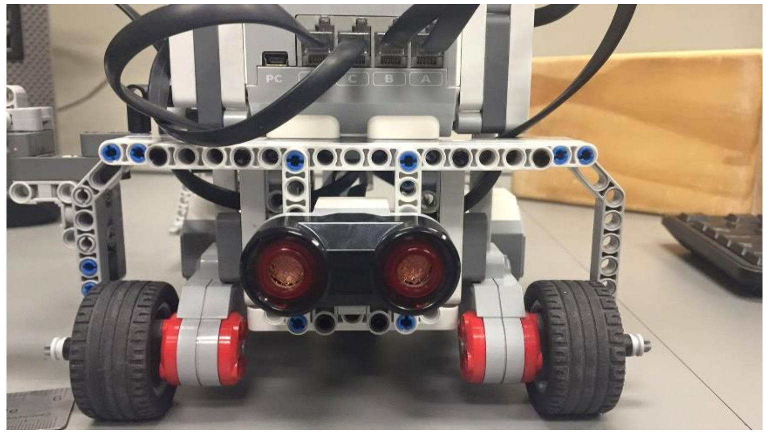


Figure 2 Ultrasonic Sensor Placed in the middle for better obstacle avoidance

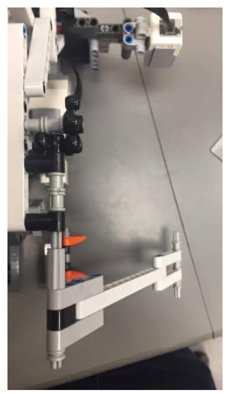


Figure 4 Distance between the mechanical arm And the Sensor is optimized

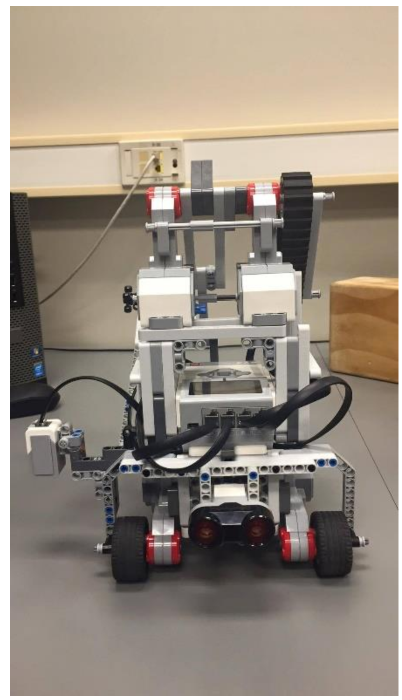


Figure 1 Front view of the robot

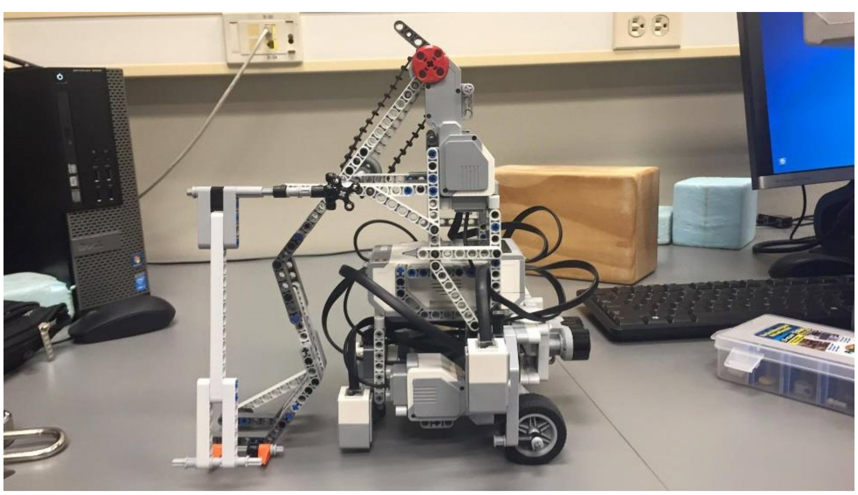
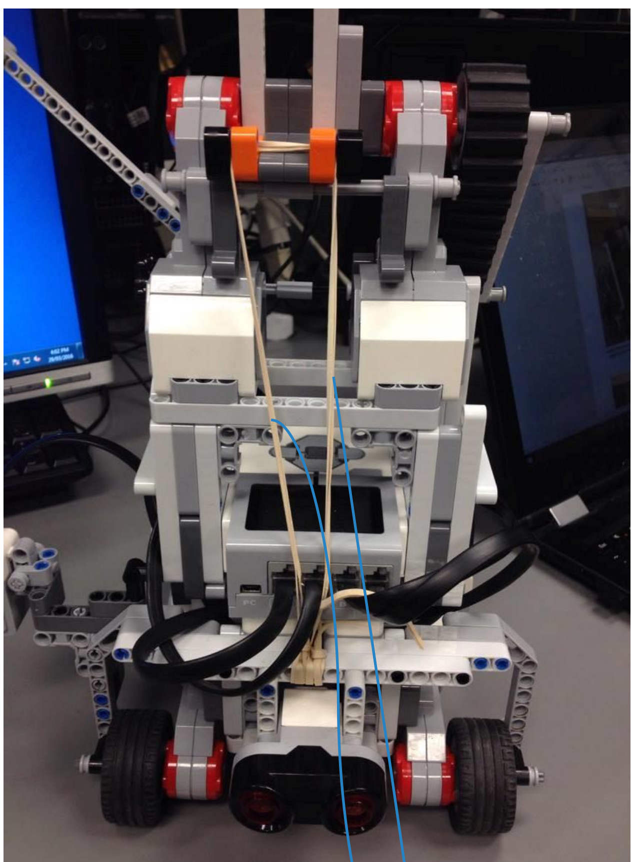


Figure 5 Side view Of the Robot

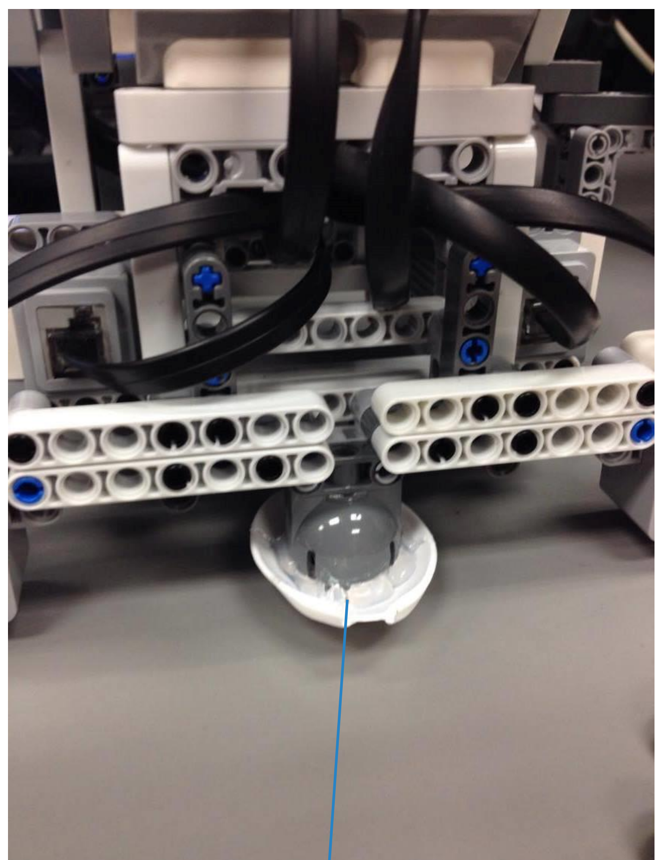
WEEK 5: Version 1.21 of Robot

29 March 2016
Author: Intesarul Khan (Team 11)

This week's hardware modification was made with the main objective of adjusting the robot's throwing mechanism for better release. Alterations were made to the robot to strengthen its base so that it can perform the tasks effectively. Furthermore, we have improvised the functionality of the catapult for better release and also attached rubber bands to the model for more powerful shooting mechanism. For the defense mechanism we decided to navigate the robot in the front of the goal post so that it can work act as a barrier. We might further change the way the robot operates its defense mechanism for a stronger defense Plastic spoons were added to base of the ball bearings so that the gaps between boards did not interrupt the robot's navigation. The whole hardware needs to be modified again as some parts of it is not symmetrical and is not as a rigid as we would have liked. We also created an LDD design which has been uploaded with the hardware documents. We are a bit behind schedule in testing the robot so further improvements would be made once testing is done



Rubber bands for better release



Plastic Spoon for better navigation

WEEK 6: Version 2.0 of the Robot

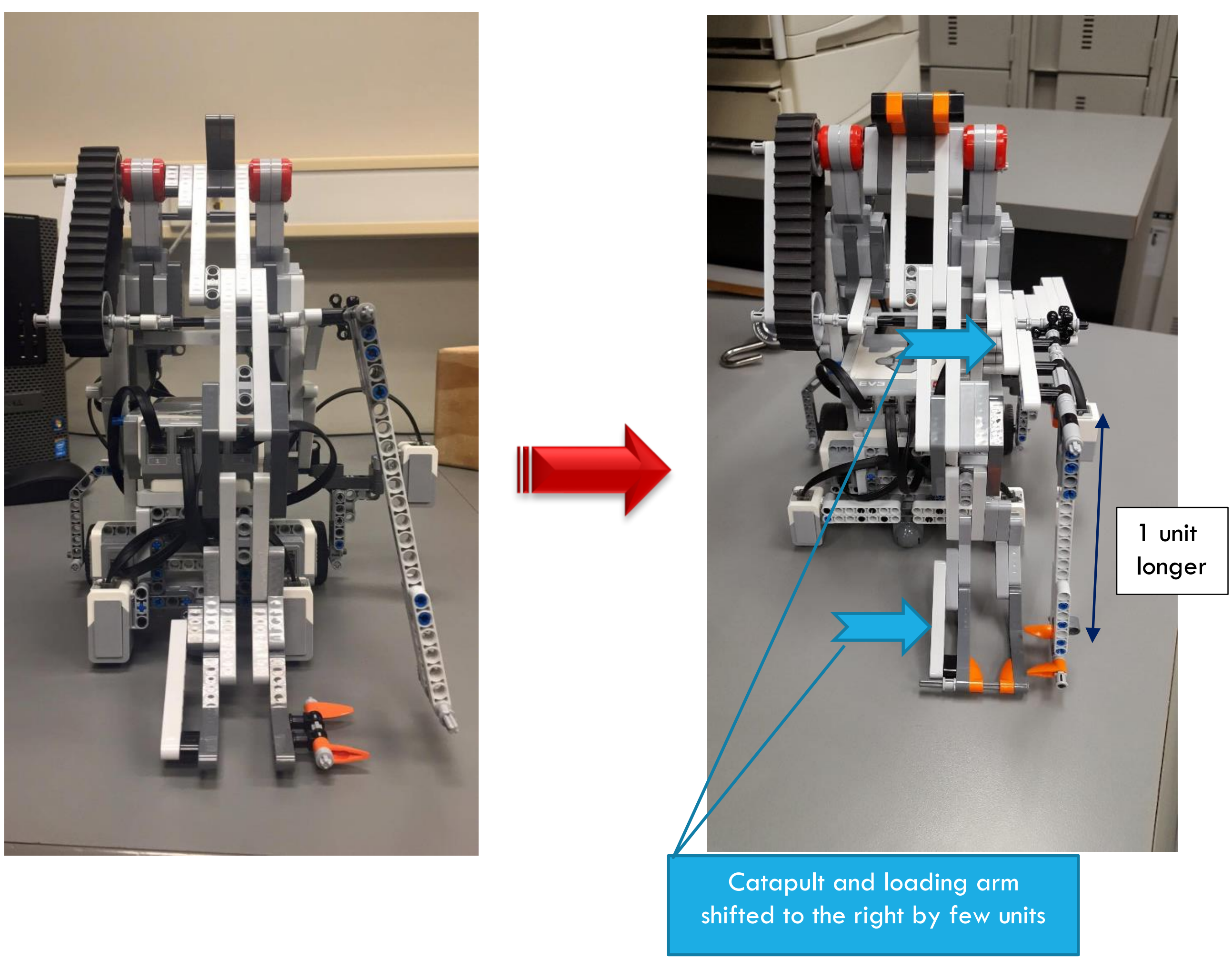
4th April 2016
Author: Intesarul Khan (Team 11)

This week we worked on making the robot as compact and sturdy as possible for the final competition. We made sure that all the sensors and motors were connected properly. The issues we faced when testing out the robot was evenly distributing the weight of the robot because it is irregular then the robot is having a really hard time traveling in a straight line.

Moved the catapult one unit to the right, the loading mechanism two units to the right

Date of modification: April 2nd, 2016

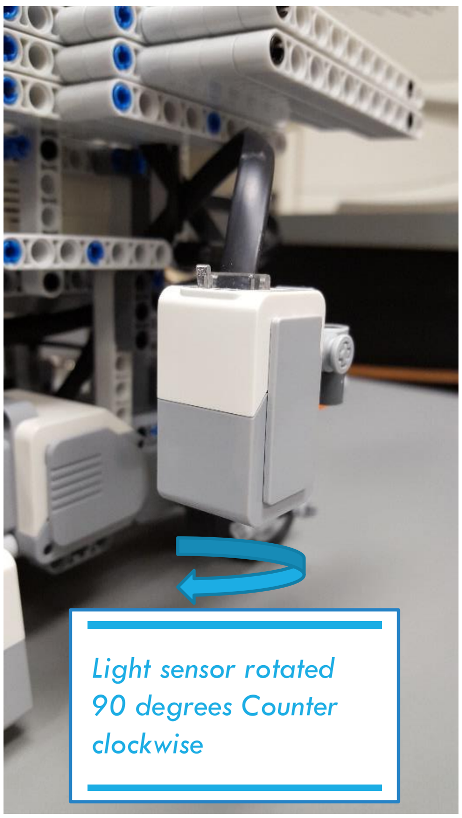
Previously we had the catapult and mechanical arm placed immediately at the back of the robot. This caused uneven distribution of the weight of the entire mechanism. Furthermore, we failed to load the ball onto the catapult consistently and only one time out of ten the ball used to be loaded onto it. The mechanisms were in close proximity to each other and loading it onto the catapult efficiently was difficult. This also ensured better distribution of weight for the robot. All the unit shifting alterations were made to align the loading mechanism to where the ball is going to be. The arm for kicking the ball onto the catapult was made a unit longer and reinforced.



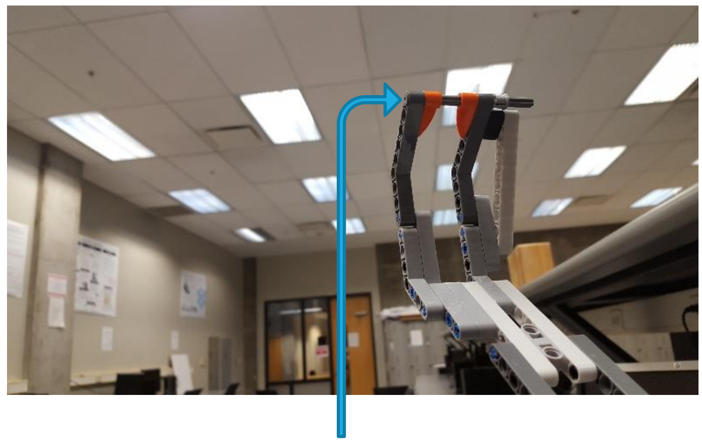
Further Alterations were made to the design as follows

Date of modification: April 2nd, 2016

The ramp from the loading mechanism was removed to make the design much simpler and easier for operation. During testing we faced a lot of difficulties when placing the ball directly under the light sensor. To correct this the light sensor for ball detection was rotated by 90 degrees counter clockwise. This ensured that that the wheels were in line with the sensors. Finally, the ramp at the end of the catapult was also adjusted so that the ball does not fall off during loading. The model was made more rigid by adding further blocks to the opposite side of the mechanical arm for better distribution of weight over the robot.

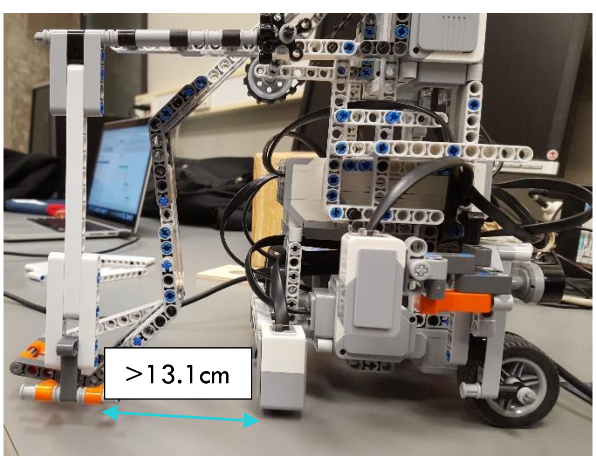


Light sensor rotated 90 degrees Counter clockwise



An axel was added to the end of the catapult so that the ball does not fall off during loading. This allowed the loading operation to be successfully carried out 10 times out of 11. This ensured better efficiency.

The Mechanical Arm was made 1 unit longer and cones were added at the end of the arm for better push. This improved our loading results significantly.



The distance between the light sensor and the mechanical arm needs > 13.1cm for pushing the ball onto the catapult. Through trial and error we figured that 13.1 cm was actually the optimal distance.

Advantages of our Final Hardware Design

- Uses single motor for both the mechanical arm and the catapult.
- Catapult on back of the robot and mechanical arm on the side of the robot are high enough to avoid hitting the walls on the side.
- Robot fits within one block.
- Only three motors used.
- Rechargeable battery used.
- Light sensor on the side of the robot which makes it easier and faster to detect the ball.

Disadvantages of our Final Hardware Design

- The centre of gravity is to the right of the robot
- The ball does not load smoothly onto the catapult
- Obstacle avoidance relies on the block being right in front of the robot

Review

We have also taken the size of the robot into consideration and have made sure that it fits in a single block with the mechanical arm raised up. However, due to the uneven distribution of the weight our robot does not travel in a straight line. This version of our robot is still not the final hardware design. We need to distribute the weight more evenly. We are late on testing and have to make adjustments accordingly once it is done.

PICTURES OF FINAL DESIGN