UNTITLED-8

Engineering Lab Notebook

FTC
FIRST Tech Challenge

hot shot

Team# 3515

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Date: 9/18/09

Meeting #1

Task	Reflection
Finish base robot	We finished the majority of the base robot in two meetings.

Finish base robot

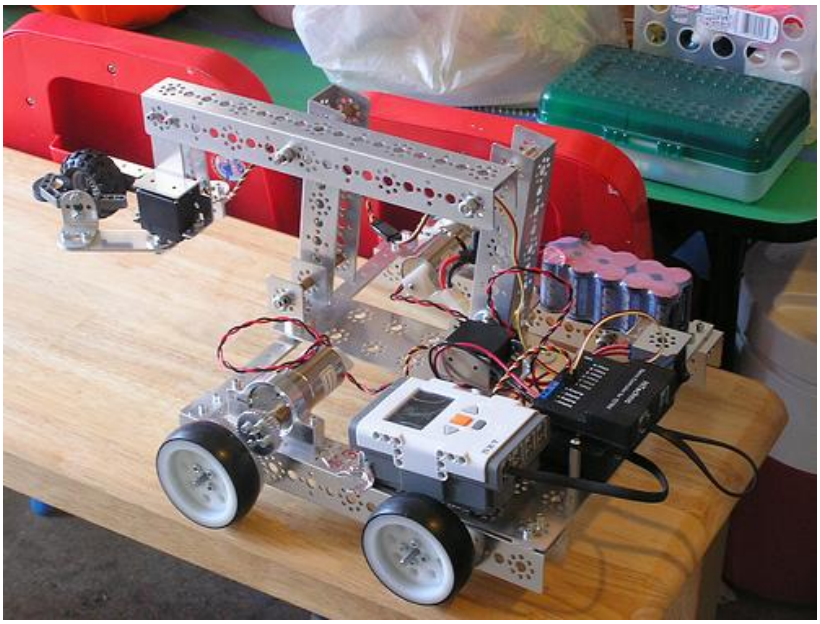


Figure 1: **Completed base robot**

The base robot was not of our design, rather this was provided to us by ORTOP FTC to help teams get started. This would give us a basic chassis with four wheels, the rear being driven by DC motors connected to a controller. In addition there was a servo controlled robot arm. This base robot was something to cut our teeth on, and see if we could actually figure out how to program. They also gave us a ModularC program to help us get started with robot-C.

9/18/09

Meeting #1 continued

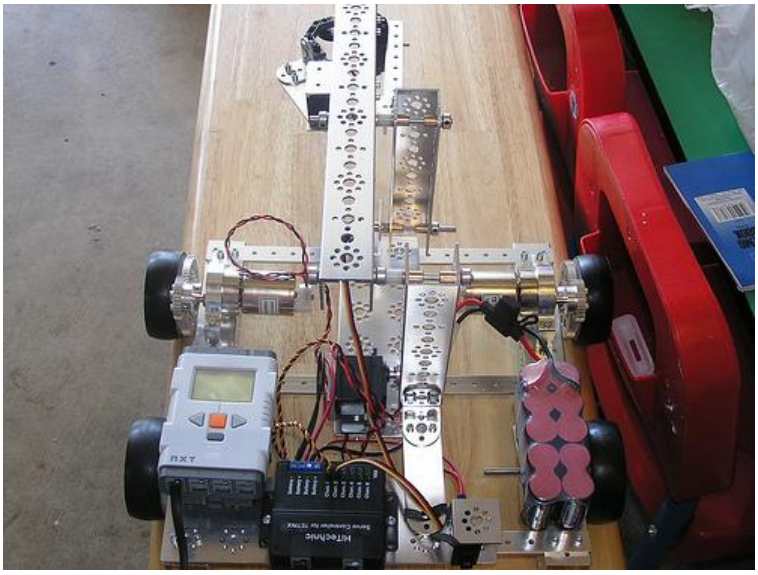


Figure 2: **Completed base robot**

Some other issues we encountered were mounting the NXT and servo glitching on the grabber. For some reason the servo on the grabber was shaking but wouldn't rotate at all. We later tested the setup with a new servo and everything worked. We also had an axle hub shortage.

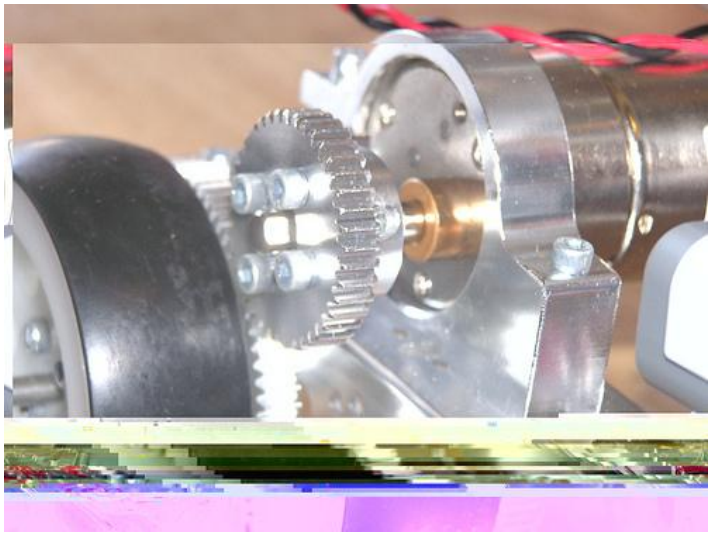
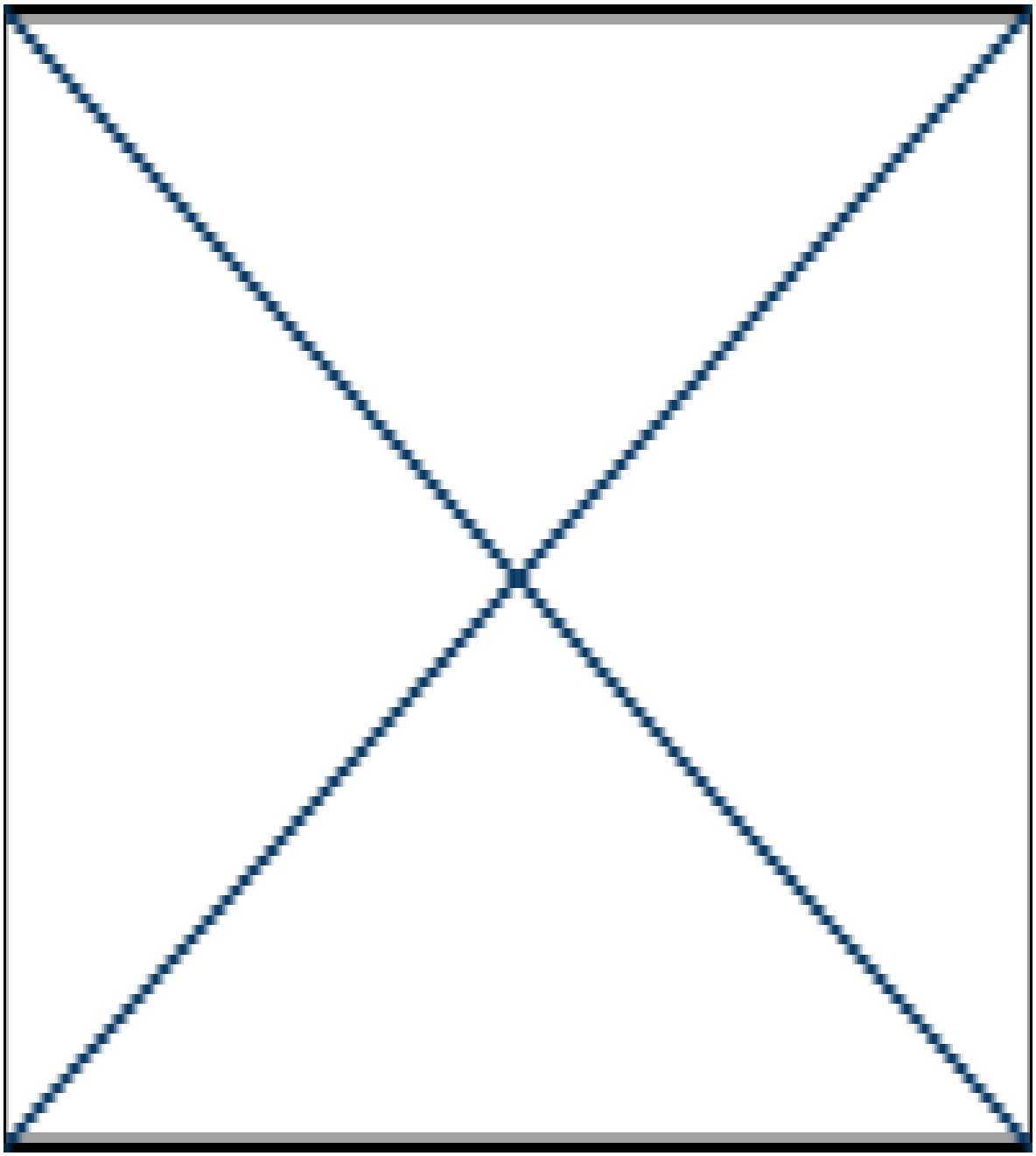


Figure 3: **Base Gear Train**

9/18/09



Recorded by: A.L./A. F.	**Date:** 9/18/09	**Reviewed by:** N.O.	**Date:** 10/26/09

9/21/09

Meeting #2

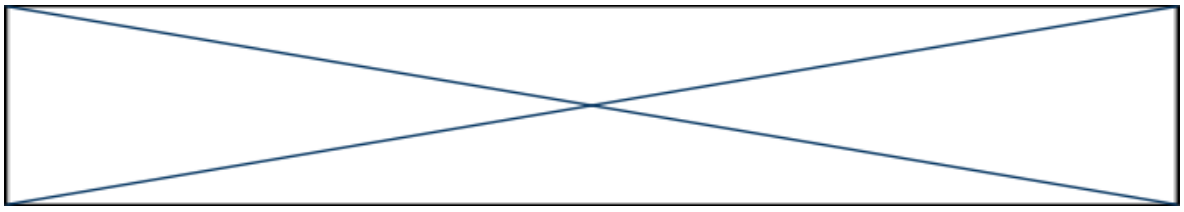
Task	Reflection
Download programs to base robot.	We had some problems downloading the program to the robot, but we solved it by looking for RobotC help online both on the RobotC forums and through other sites found on the web.

Downloading programs to practice robot

```
(
   // Move Forward
   Motor [motorR] = 100;
   Motor [motorL] = 100;
   Wait1Msec(4000);

   // Move Backwards
   Motor [motorR] = -100;
   Motor [motorL] = -100;
   Wait1Msec(4000);
)
```

Problem downloading to practice robot and the wrong platform was selected. We needed the robot to run but the program wasn't working. We looked at a few websites and found good nuggets of information to solve the problem.



Recorded by: A.L./A.F.	Date:9/21/0	Reviewed by: N.O.	Date: 10/26/09

9/25/09

Meeting #3

Tasks	Reflections
Fixing Bluetooth	Found out Bluetooth was off, though we still couldn't connect.
Attempting to run RobotC	Boot Successful

Fixing Bluetooth

Three meetings into the season and we still couldn't figure why our Bluetooth was not running. Towards the end of the meeting Sean remembered from last years FLL season that the Bluetooth mode was turned off on the NXT brick. Once we turned it on everything connected the first time but we couldn't get it to after that.

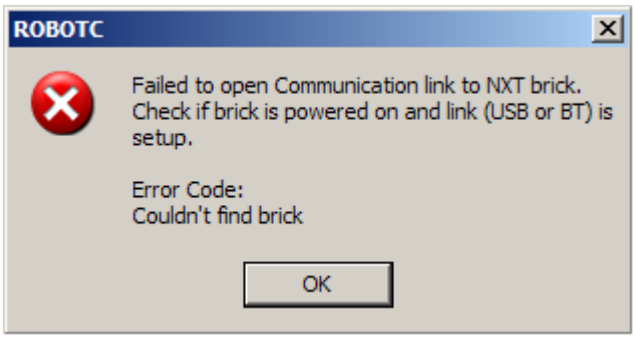


Figure 4: **RobotC connection error**

Attempting to run RobotC

Today we successfully for the first time ran RobotC and connected the NXT to the computer via Bluetooth. We did a little driving around of the robot on the garage floor. Though we had it running once today we have had problems connecting to the Bluetooth on other occasions.

9/25/09

Meeting #3 continued

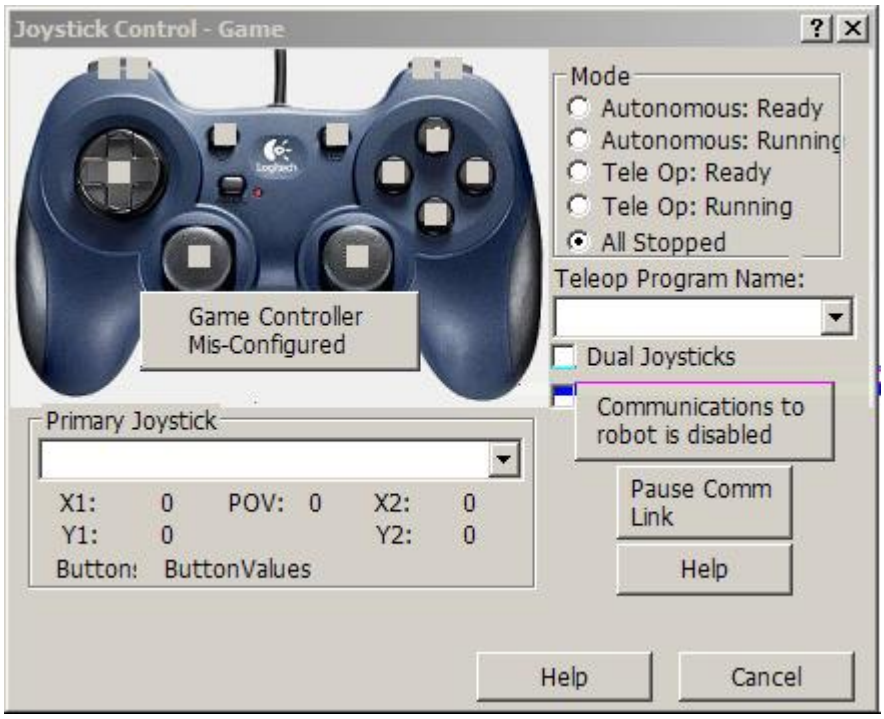
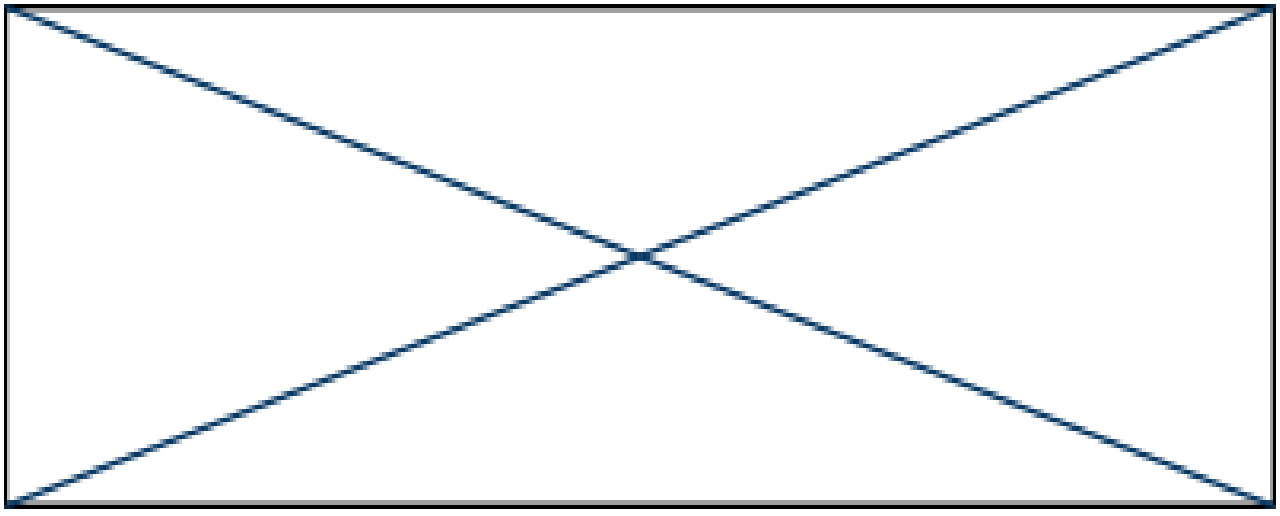


Figure 5: **RobotC controller run screen**



Recorded by: A.F.	**Date:** 9/25/09	**Reviewed by:** N.O.	**Date:** 9/25/09

9/28/09

Meeting #4

Task	Reflection
Officially choose team name	On majority vote, we chose the team name of *Untitled-8*, the name of our FLL team last year.
Fix Servo Issue	The claw didn't work, and we still don't know why. The servo is shaking though.
Work on ball storage	Decided to make a conveyor belt using 1 by 6 LEGO blocks.
Work on the ball shooter	Our designed failed in more than on way. This will definitely need re-designing.
Work on the ball collector	Decided to make rotating claws that would scoop the balls as they reached their range.

Ball Shooter

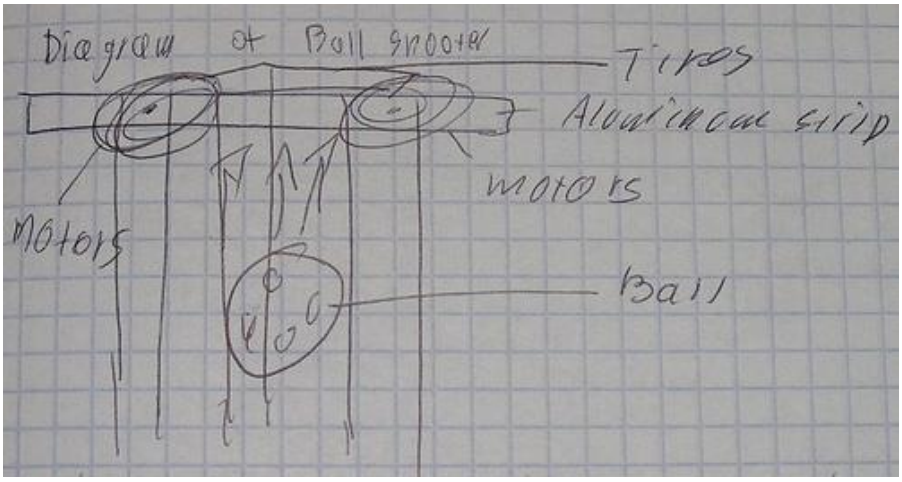


Figure 6: **Ball shooter concept**

9/28/09

Meeting #4 continued

Our design consists of four aluminum strips, two Tetrix tires, and two Tetrix motors. The ball will roll up to the spinning tire and hopefully shoot them out of the robot into the goals.

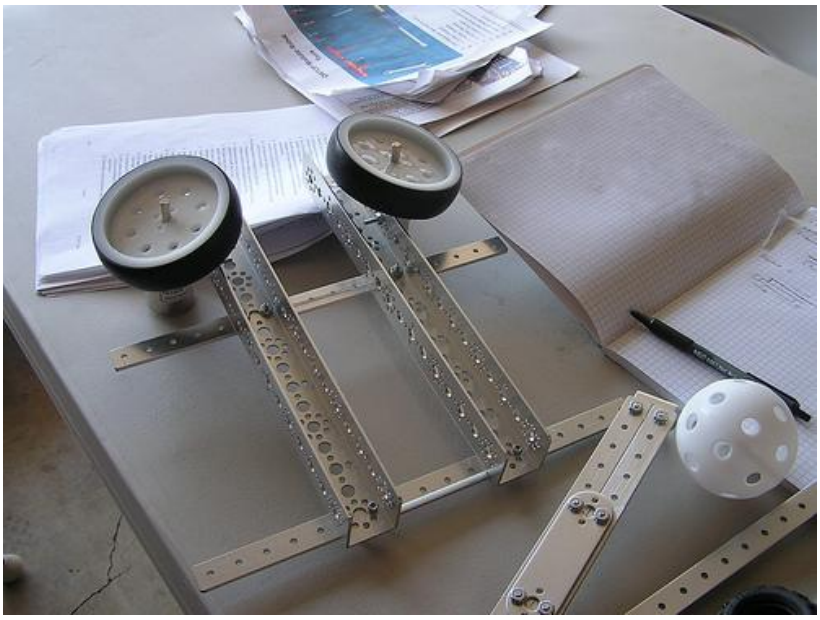


Figure 7: **Ball shooter in the building stages**

Once this concept was tested we found out that we had a number of issues. The first one was that we where not getting enough speed from the Tetrix motors and the gears didn't allow us to do what we wanted. The unit was also very large and heavy. It could only be made a bit smaller. The other problem we had was that the tires are too slick. They touch the ball and spin it but don't have enough grip to shoot them. When we aimed the unit down the ball only went a maximum of 3''. There were definitely not the results we were looking for.

Ball Collector

This design is still in the concept stage, but we found some claws from LEGO a Bionicle set that would bring the wiffle balls into the robot.

9/28/09

Meeting #4 continued

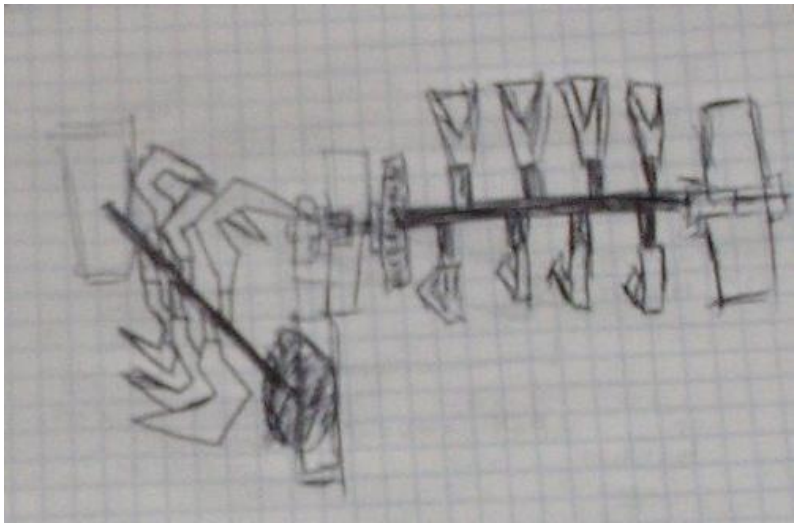


Figure 8 **- Ball collector concept**

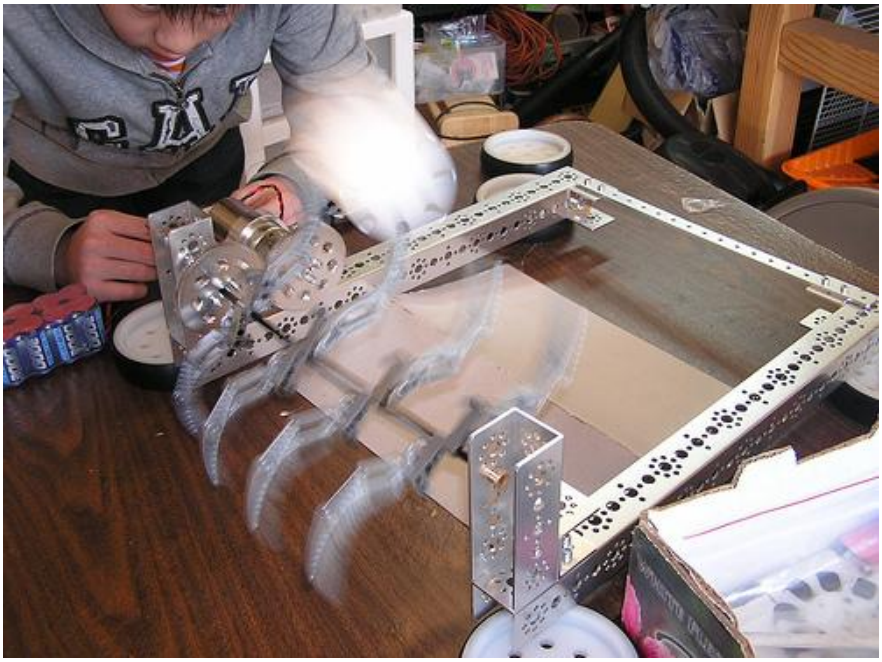


Figure 9 **- Ball collector built and running**

Recorded by: S.K. & V.C.	**Date:** 9/28/09	**Reviewed by:** A.F.	**Date:** 10/30/09

10/2/09

Meeting #5

Task	Reflection
Design a storage and delivery conveyor belt.	We have nothing to show for this yet, but we may use LEGO Technic rods and zip-ties to create a conveyor belt to carry the balls up to the shooter.

Ball delivery conveyor belt

We've found two plausible designs. We are right now only focusing on one.

The first we have nothing to show for yet but we may use LEGO Technic rods and zip-ties to create a conveyor belt to carry the balls up to the shooter.

The second concept involves a tire rolling back and fourth that will deliver balls one at a time to the shooter from the storage.

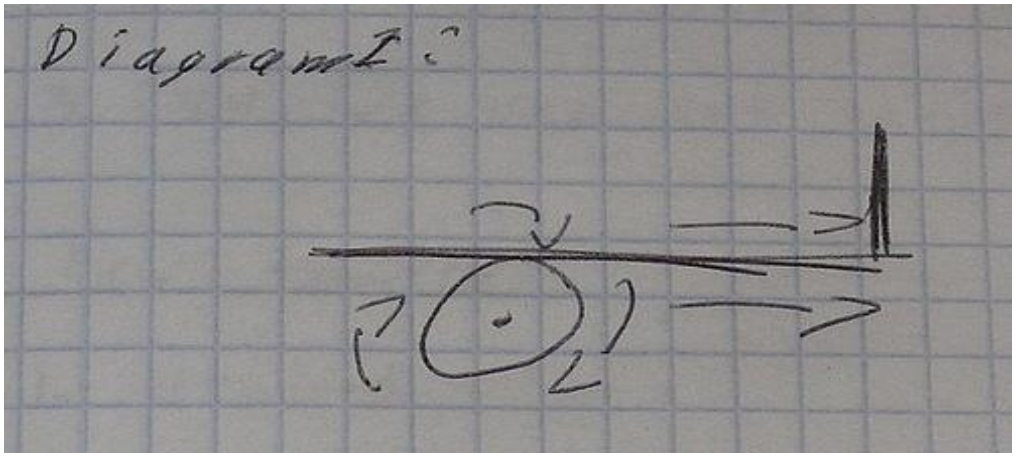


Figure 10**: Ball conveyor belt concept**

Recorded by: A.F.	**Date:** 10/2/09	Reviewed by: N.O.	**Date:** 1.18.10

10/5/09

Meeting #5

Task	Reflection
Look more into conveyor belt for balls.	Another idea would be to use a non-slip pad as a belt for the ball delivery device.
Improve current ball collector.	Masking tape was added to the ball collector's claws so balls don't get stuck on them and go through smoothly.

Conveyor belt designs

Another idea is to use a a non-slip pad a a conveyor belt and have something sticking out of it to carry the balls up. This would likely go between the two metal strips of the ball shooter to reduce space and to bring the balls to the shooter. We could use LEGO tires and an NXT motor to power it.

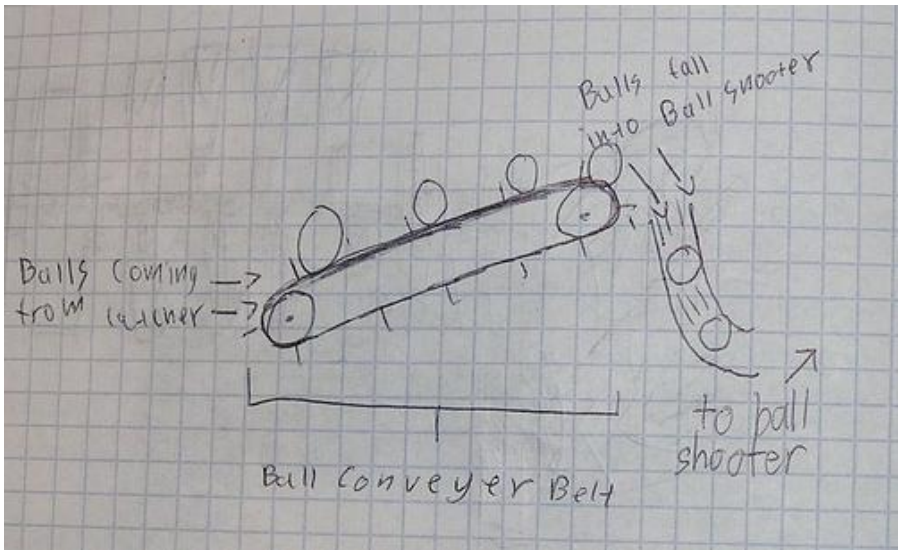
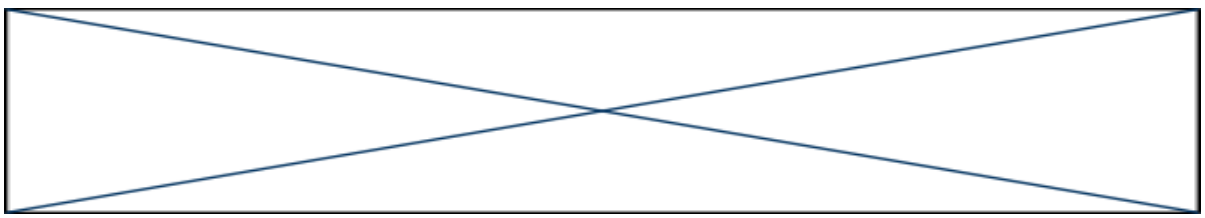


Figure 11**: New LEGO conveyor belt concept**



10/5/09

Meeting #5 continued

Improve ball collector

The old ball collector would often get caught because the parts where not flexible. This could lead to stripped gears so we obviously need to work on this. The claws would also get stuck in the holes in the wiffle balls and this would either jam the collector or shoot them at out the wrong way.

We put some green masking tape over the claws, and it no longer gets caught this seems like a good solution for now.

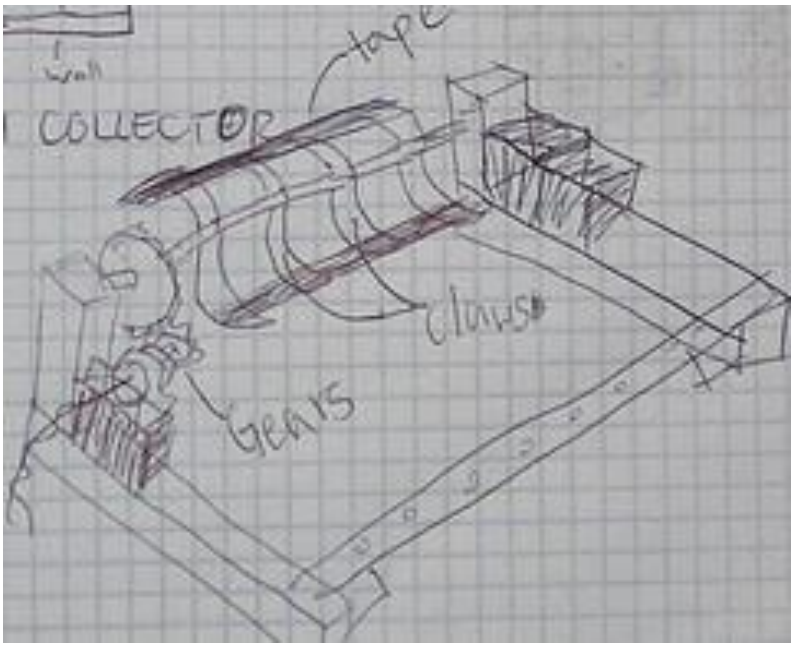
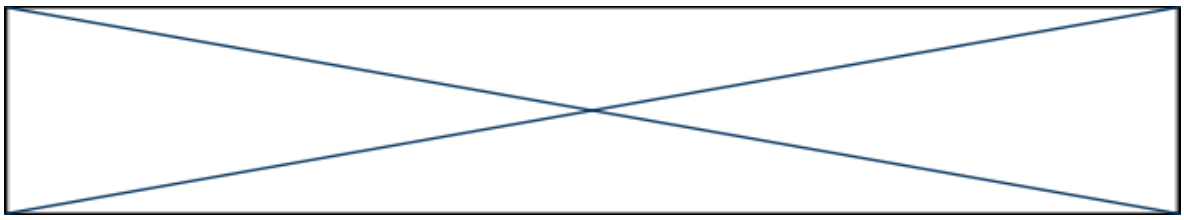


Figure 12**: Drawing of claws with green masking tape installed**



Recorded by: A.F.	**Date:** 10/5/09	**Reviewed by: N.O.**	**Date:** 1.18.10

10/6/09

Meeting #6

Task	Reflection
Re-visit ball conveyor belt.	No concepts have been successful so we are going to put it to rest for now.
Work on ball collector	We realized the masking tape is not an allowed material, so we may try to use some non-slip pad.

Work on ball collector

We recently put green masking tape on the claws to keep them from catching or getting stuck in the balls. After a quick review of the game manual we found that the tape we used is not an allowed material. We may use some non-slip pad, but if it doesn't work then we will have to create a new ball collector device.

We also tried string.

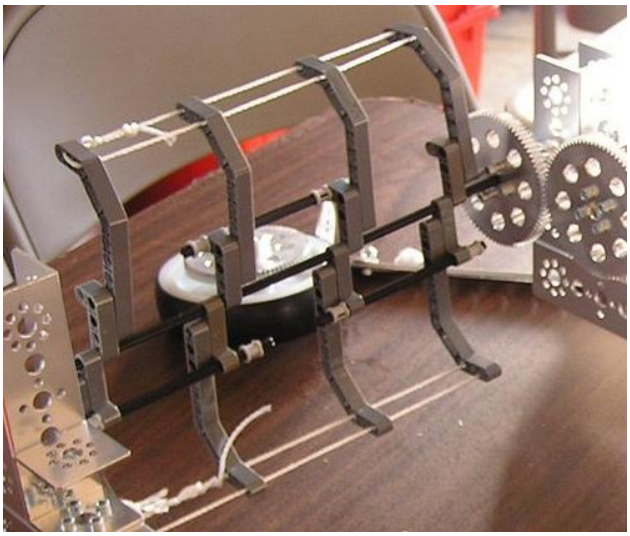


Figure 13: **Ball collector with string to grab balls**

Recorded by: A.F.	**Date:** 10/6/09	**Reviewed by:** N.O. & P.S.	**Date:** 1.18.10

10/19/09

Meeting #7

Tasks	Reflections
Find new ideas for ball shooter	We came up with three solid ideas.
Ideas for drive-train	Still in progress.
Work on current ball shooter design	We made very good progress on it.

Ideas for ball shooter:

Our original idea used the 4'' Tetrix wheels. The rubber on them is very hard and not very sticky. We noticed the speed was too low and the tires were too slick so we made the diameter of the holes in Lego tires bigger. These now fit tightly on the metal Tetrix axles.

a. The first one we found was a design similar to a baseball pitching machine. This design is very similar to our current shooter. The only difference is that the concave wheels much like the image below.

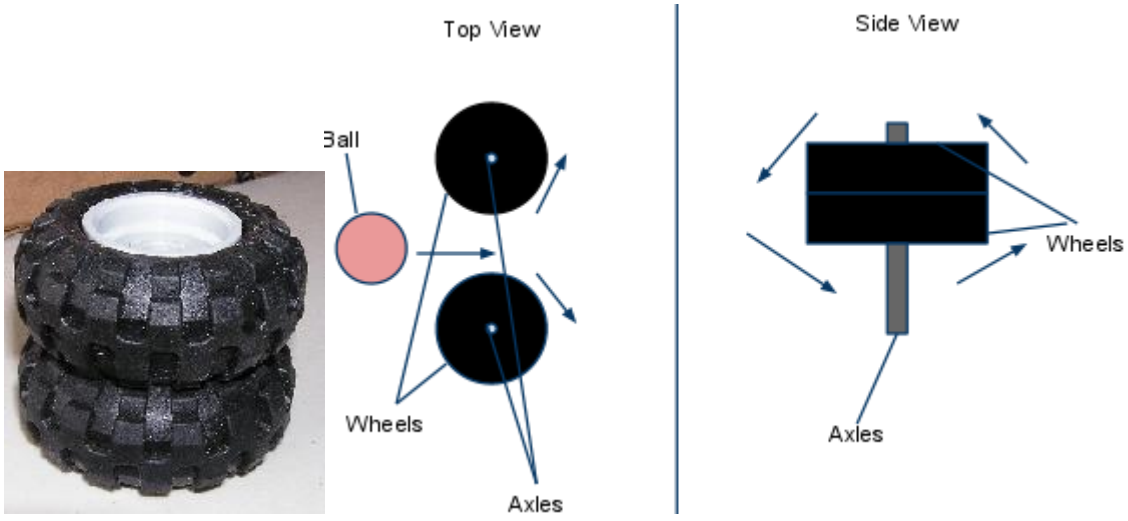
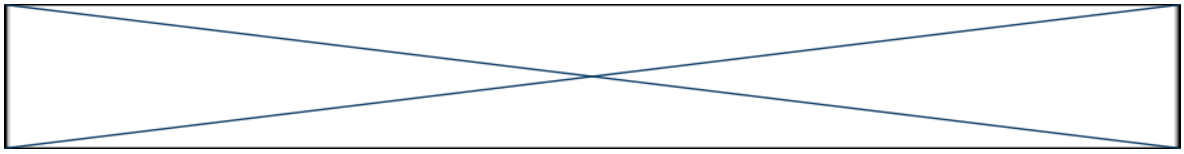


Figure 14**: Lego Tire Concept**



10/19/09

Meeting #7 continued

b. We also found a slinging arm idea. Here is an illustration of b.

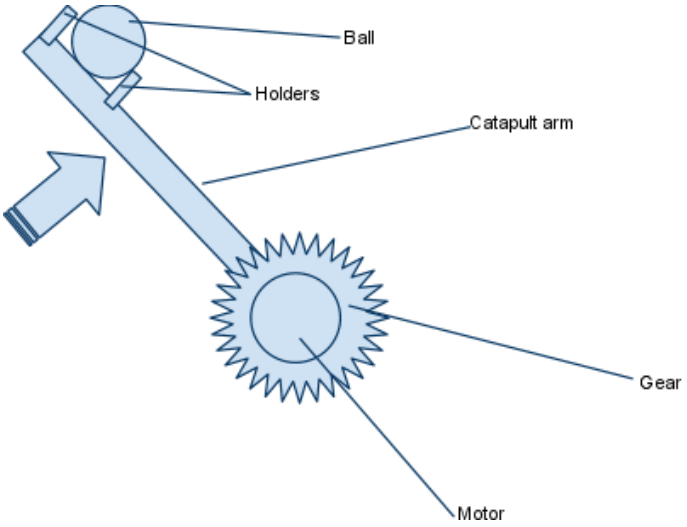


Figure 15**: Slinging Arm Concept**

c. We also came up with a scissor arm idea. Here is an illustration of c.

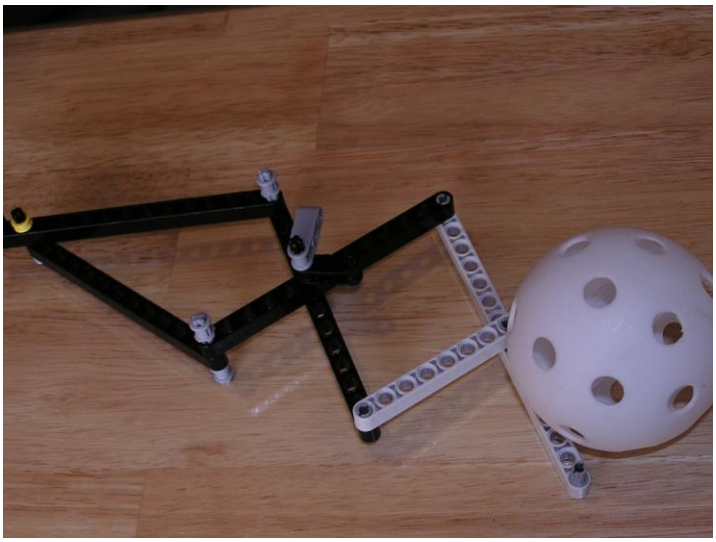


Figure 16**: Scissor Arm Concept**

10/19/09

Meeting #7 continued

Ideas for drive-train:

Four-motor drive-train halfway completed; now will use two motor controllers that will have each side synchronized.

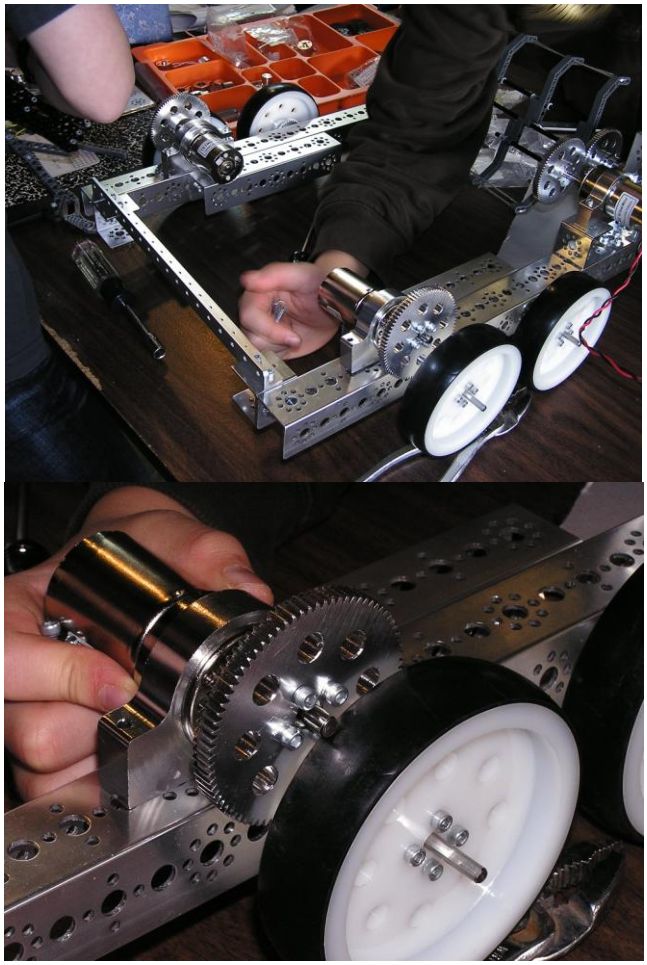


Figure 17**: Drive train Improvements**

10/19/09

Meeting #7 continued

Modification of current ball shooter:

We changed it from a big Tetrix wheel on each side to two Lego Wheels on either side. They grip better and the dual tires are concave which allow for the balls to fit in between the two tires.

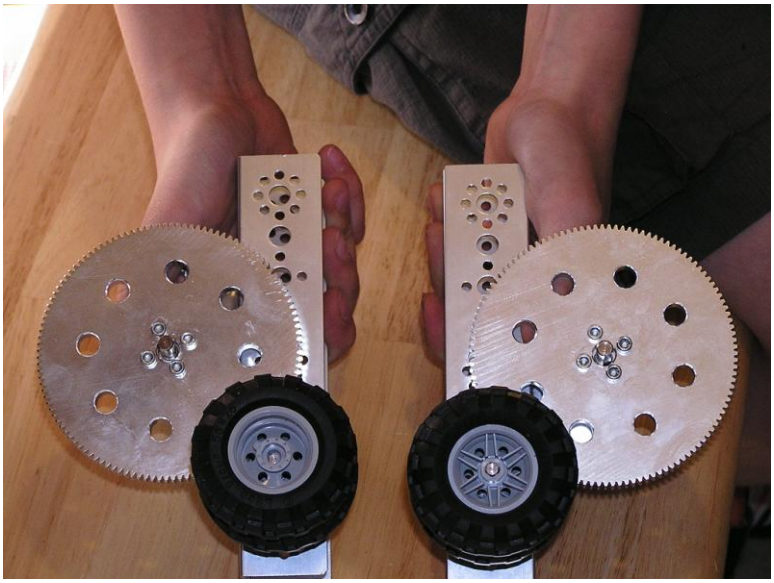


Figure 18**: Modification of Ball Shooter**

Recorded by: S.K.	**Date:**10/19/09	**Reviewed by:** W.H.	**Date:** 10/19/09

10/26/09

Meeting #8

Tasks	Reflections
Make ball shooter have faster spinning wheels	We used NXT motors and gears instead of the Tetrix gears because of the rage of gears to choose from.
Work on drive train	We successfully completed
Create prototype for ball collecting ramp	We made one first out of cardboard but we didn't get to a final model (aluminum, fiberglass?) one yet.

Modified Ball Shooter

We decided that since the Tetrix gears cannot give enough speed to the wheels (due to the lack of gears with fewer teeth). We are going to use LEGO gears and motors instead. Nathan built a prototype at his house and when tested it worked well. He brought the prototype to the meeting and we built two replicas of it. We then modified it and combined it with Tetrix parts. It ended up shooting the wiffle ball several feet which is a record (our old one was 3 inches).This was the result:

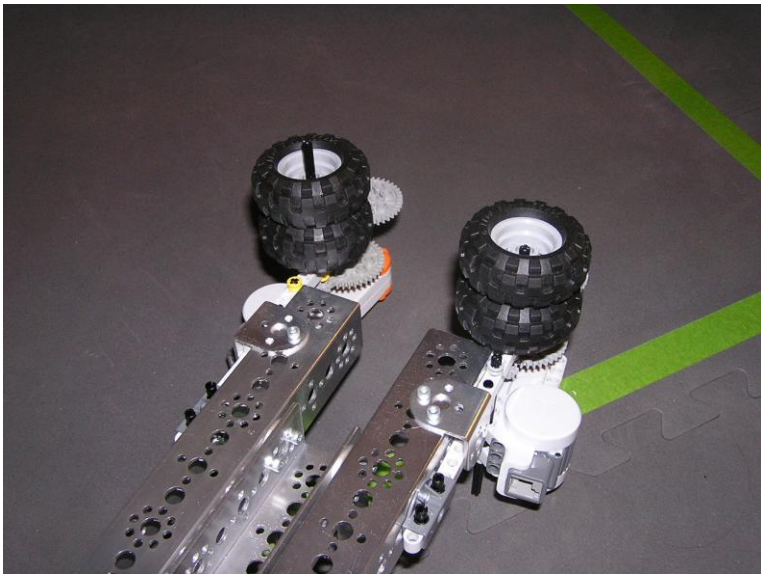


Figure 19**: LEGO/Tetrix ball shooter**

10/26/09

Meeting #8 continued

Drive Train

We completed the drive train with direct gear contact (no sprocket and chains) omni wheels were added to the front to reduce skid steer. We have not yet been able test it yet.

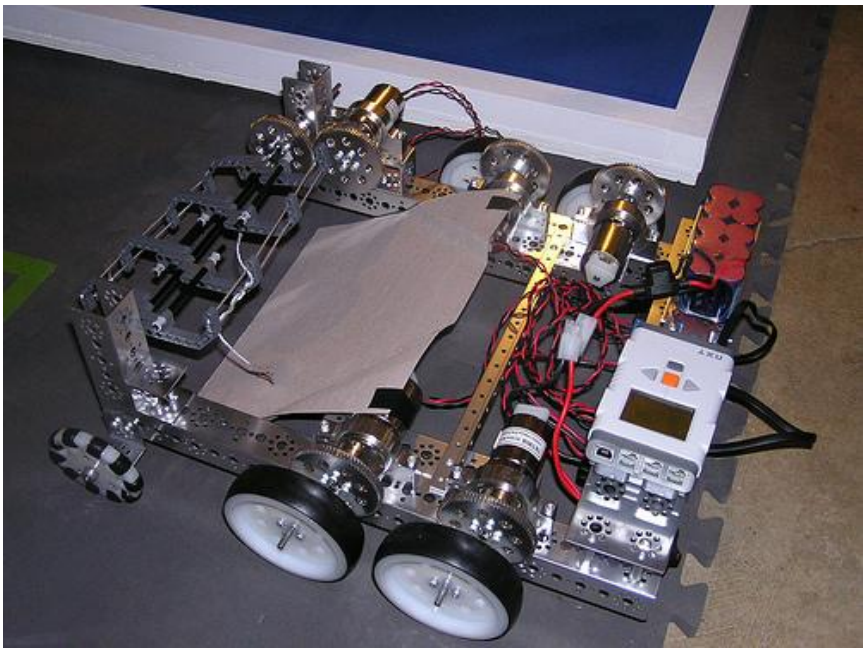
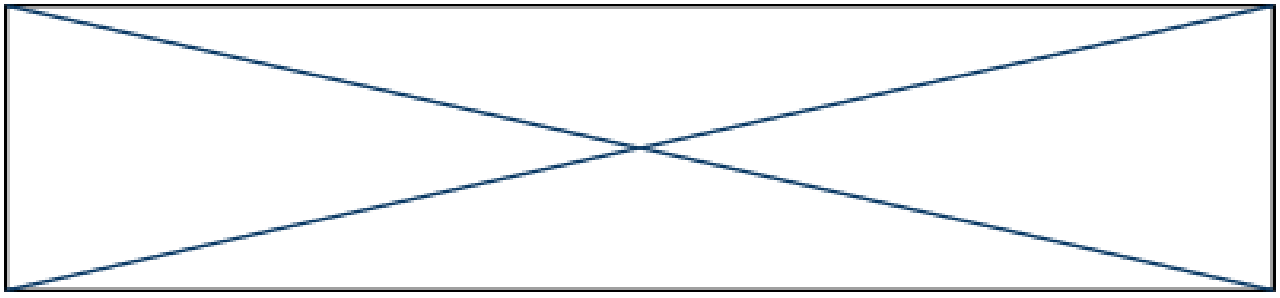


Figure 20**: Robot chassis with collector mounted**



Recorded by: B.C.	**Date:**10/26/009	**Reviewed by:** A.F.	**Date:** 10/30/09

10/30/09

Meeting #9

Task	Reflection
Make ball shooter shoot further	Since we moved to the LEGO gears we have been able to change the gearing thus speeding up the rotation and shooting the balls further.
Write simple program to run robot chassis and ball collector	We are still having an issue a need to learn more about RobotC

Make ball shooter shoot further

All we have been doing with the ball shooter is finding good ratios and a good way to attach all of the gears to the device. Two of these will be needed and the gears and shafts will have to remain steady. This likely means we'll need a support on the bottom and on the top of them.

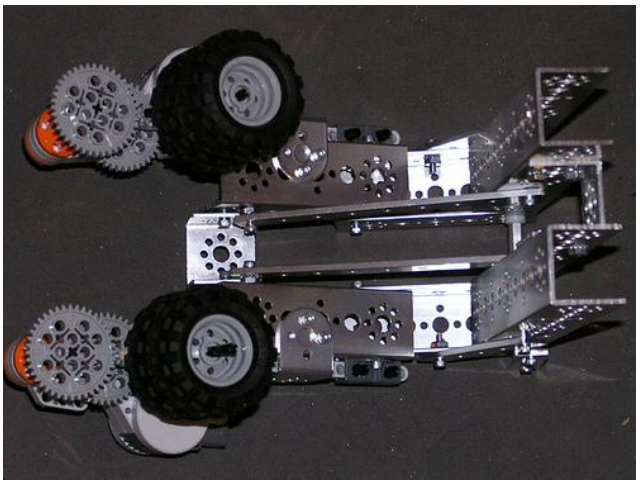


Figure 21**: More Ball Shooter Work**

We will soon take out old one apart and re-build the entire thing with more gears and hopefully a greater top speed in the end.

Recorded by: A.F.	**Date:**10/30/09	**Reviewed by:**N.O.	**Date:** 10/30/09

11/2/09

Meeting #10

Task	Reflection
Refine Ball collector	We used special flexible rods to act like brushes to sweep the balls up.
Upgrade the ball shooter	We changed the program and put it on an infinite loop which made it go faster.
Create aiming apparatus	We created a pivoting arm that allowed the ball shooter to move up and down and to change the angle.

Refine Ball collector

We ran across some flexible LEGO rods that will act as brushes to suck in the ball to out carrier or launcher. These grip quite nicely, will not catch due to their flexibility, and are available in bulk.

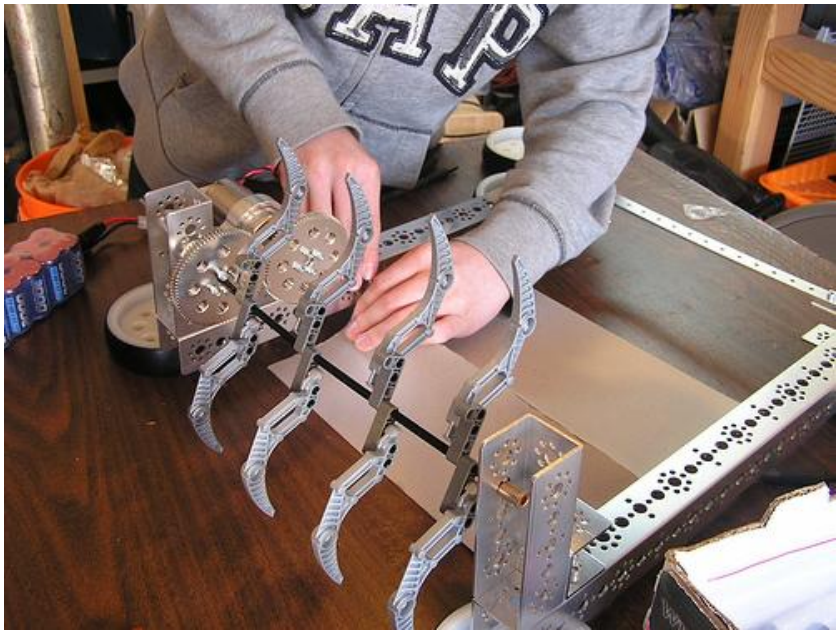


Figure 22**: Old Ball Collector Design**

11/2/09

Meeting #10 Continued

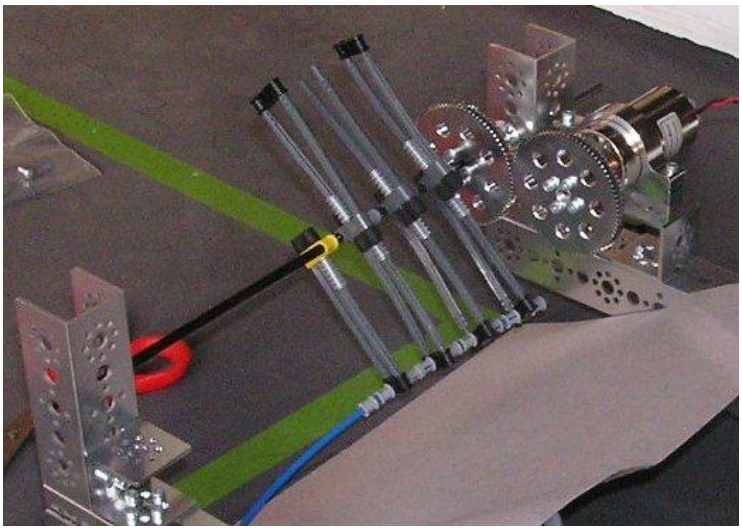


Figure 23**: New Ball Collector Design**

Upgrade the ball shooter

The previous shooters have used mainly Tetrix parts so a while back we decided to use LEGO parts and gears for more gearing (speed) flexibility. The speed was still too low so today we created another simple NXT program to run the motors at 100% power. The balls were definitely flying a good 5 feet.

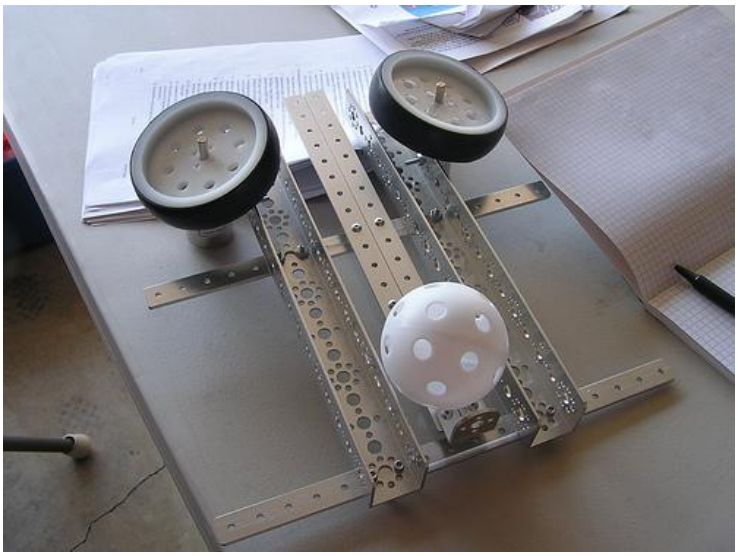


Figure 24**: Old Ball Shooter Design**

11/2/09

Meeting #10 Continued

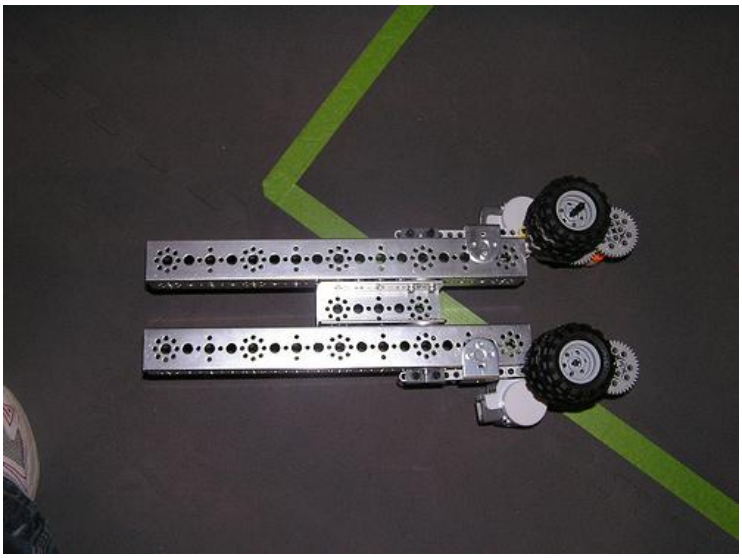
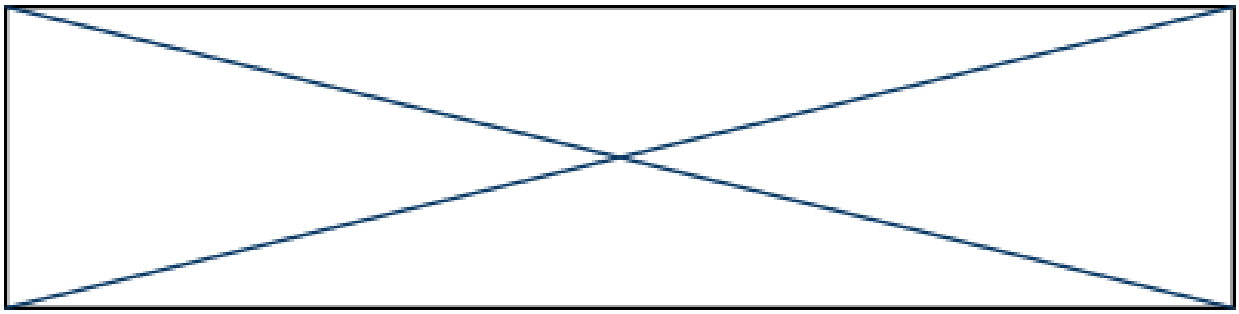


Figure 25**: New Ball Shooter Design**

Create aiming apparatus

We realized we'll need to aim the ball shooter at the goals so we came up with a design that easily allows the device to move up and down at out specified speed. This is not complete yet.



Recorded by: N.O. / B.C	**Date:**11/2/09	**Reviewed by:** A.F.	**Date:** 11.3.09

11/6/09

Meeting #11

Task	Reflection
Program the robot to test drive it.	We didn't get a test program written yet because we can't connect to the NXT brick via Bluetooth yet.
Work on ball ramp to bring balls up from the collector.	We have two sheets of plastic, Lexan (polycarbonate), and Plexiglas (acrylic). We decided to use the Lexan for the ball collector because of its strength and it was already cut to a perfect size.
Take metal off ball shooter to fit it on the robot and reduce weight.	Some aluminum was taken off under the motors to reduce weight.
Adjust gears on robot to allow all powered wheels to rotate.	All gears adjusted and they all seem to rotate.

Work on ball ramp to bring balls up from the collector

The Lexan is zip-tied to the aluminum bars, and sits on the motors. It is very firm and tightly placed. We ran the ball collector briefly and the balls rolled perfectly up the ramp.

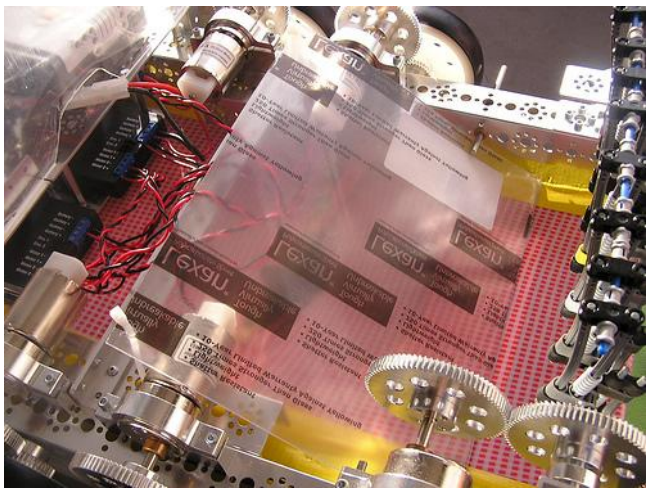


Figure 26**: Ball Shooter Lexan Ramp**

11/6/09

Meeting #11 continued

Adjust gears on robot to allow all powered wheels to rotate

We have aligned all the gears up so and adjusted the mesh so they should all work fine. We are still having problems with RobotC, so we haven't seen them all run simultaneously yet.

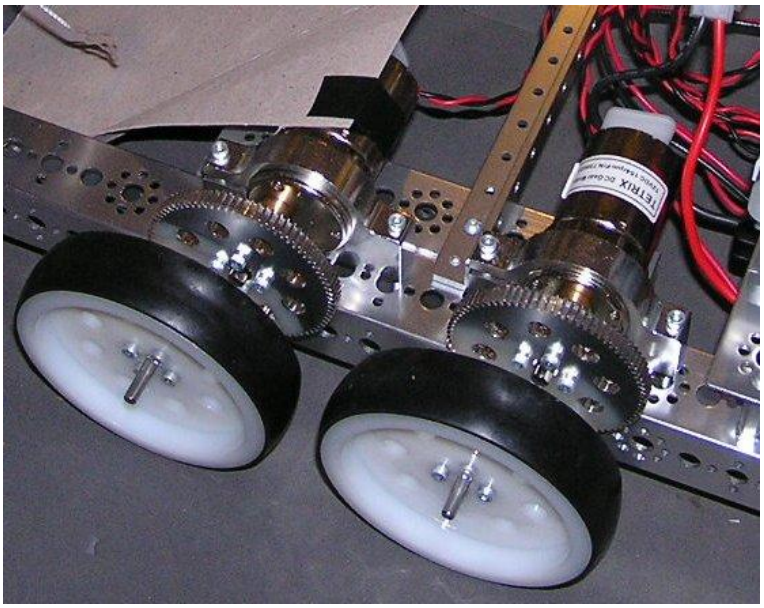
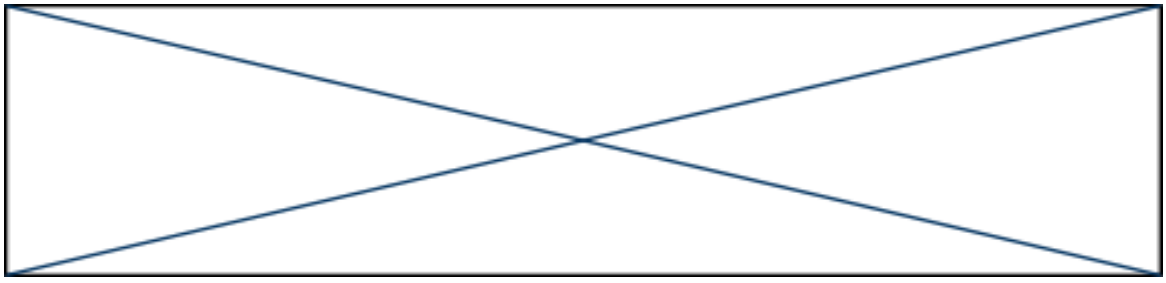


Figure 27**: Drive Train Gear Alignment**



Recorded by: A.F	**Date:** 11.14.09	**Reviewed by:** N.O	**Date:** 11.14.09

11/8/09

Meeting #12

Task	Reflection
Reduce size of ball shooter to fit it onto chassis	We successfully reduced the size and weight by almost half.
Work on ball storage system	We made a ramp to bring the balls to the storage and worked on a Plexiglas wall to bring the ball up the shooter. We don't yet have a storage system like a bucket though.
Attempt to connect robot to Bluetooth again	We solved this by connecting using the computer, get the com ports, starting game controller again, and connecting to the robot. It usually takes two tries.
Find affordable way to bend plastic	We came up with a great idea but haven't tested it yet.

Add onto ball shooter

We made the ball shooter device about half of its original size and made a gravity drop system. Once the balls come off the lift they will roll down the ramp then up another into the ball shooter, then hopefully into the goal(s).
Earlier larger shooter

Figure 28**: Ball Shooter Guiderail Concept**

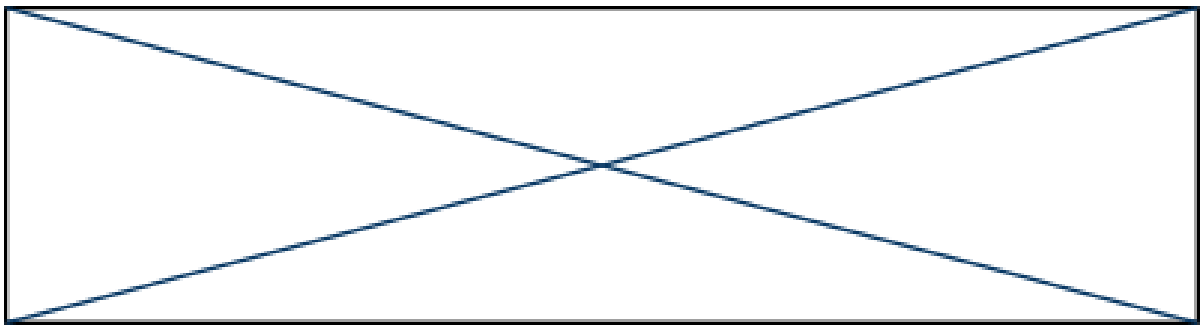
11/8/09

Meeting 12 continued

Figure 29**: Ball Shooter Guiderail Concept (View 2)**

Work on ball storage system

We got piece of Plexiglas mounted on the rear of the robot. This will both protect the electronics and act as a wall for ball to be forced against and pulled up into the ball shooter. On the front of the robot we also added a Lexan ramp. Once the balls are pulled into the robot they will go up the ramp and into the ball collecting chamber.



11/8/09

Meeting 12 continued

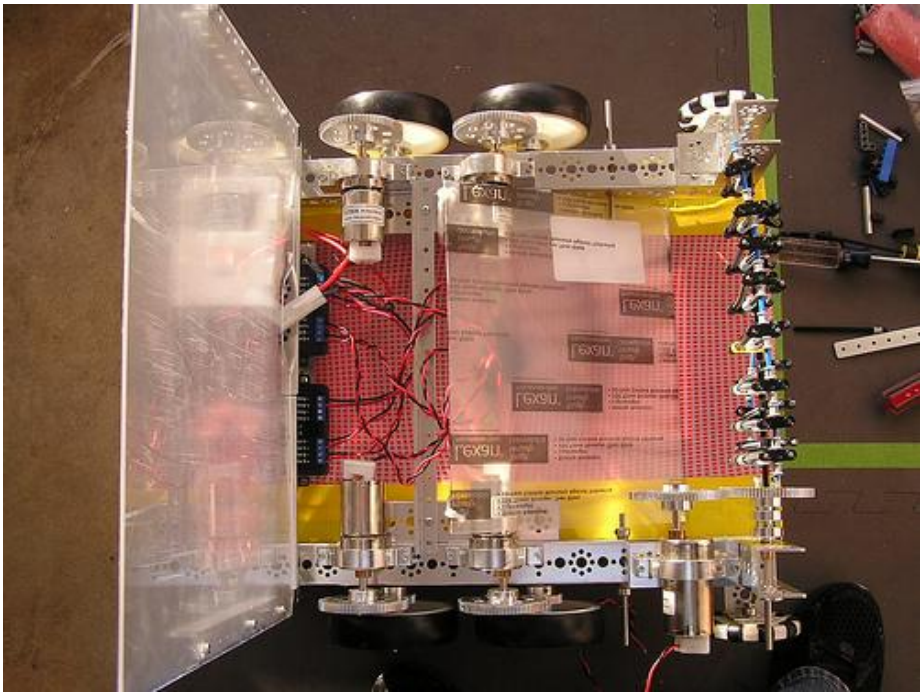


Figure 30**: Ball Transport and Storage Concept (Top View)**

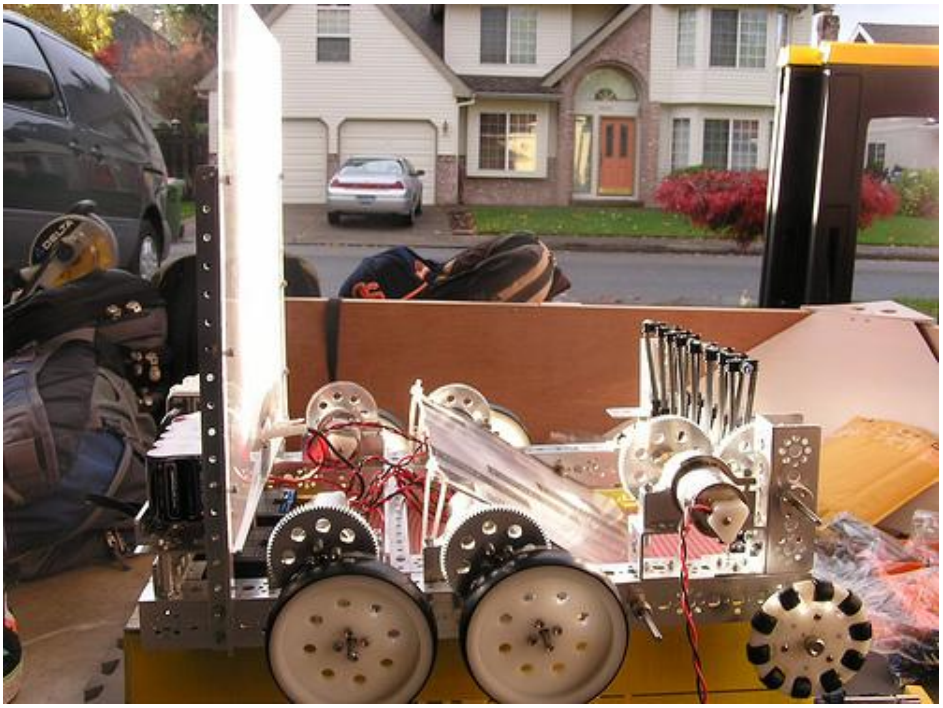


Figure 31**: Ball Transport and Storage Concept (Side View)**

11/8/09

Meeting 12 continued

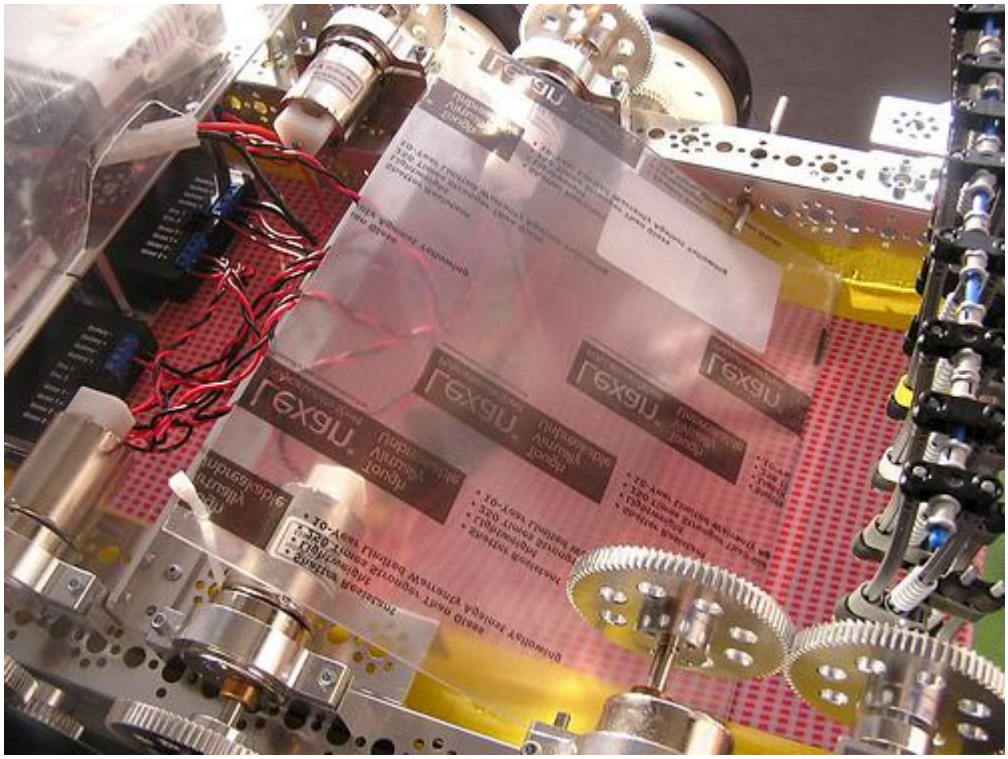
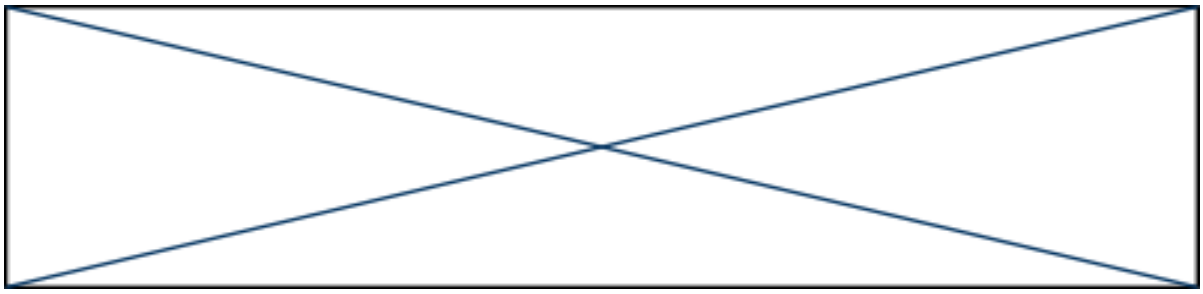


Figure 32**: Ball Transport and Storage Concept (Close-up)**

Find affordable way to bend plastic

The first way we came up with was to purchase a $40 heating element and all the supplies to build out own plastic bender. With a tallied up cost of over a hundred dollars we started searching for other alternatives.

The next idea was to use a soldering iron. This worked perfectly for bending small pieces no longer that 5'', but wouldn't work for what we needed.



11/8/09

Meeting 12 continued

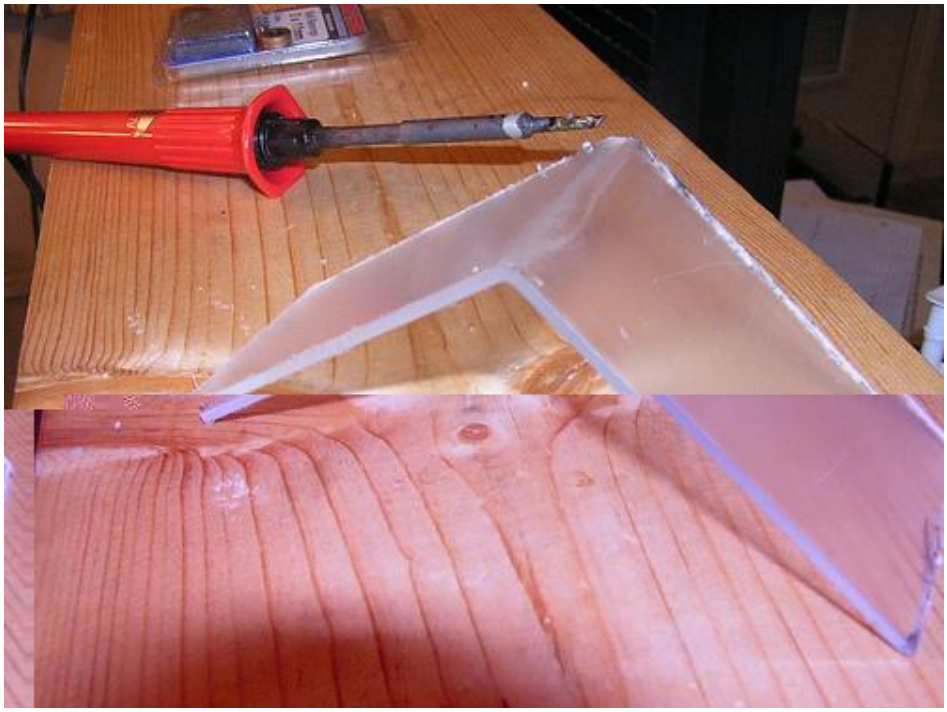


Figure 33**: Solder Iron Plexiglas Bend Method**

Our next idea was heat a steel strip with a butane lighter and hold the plastic above the hot strip until it is able to bend. We have not tested this idea out yet, but plan to as soon as possible.

Here is what it would look like. Note the Butane Lighter in this case could be replaced by a propane torch.

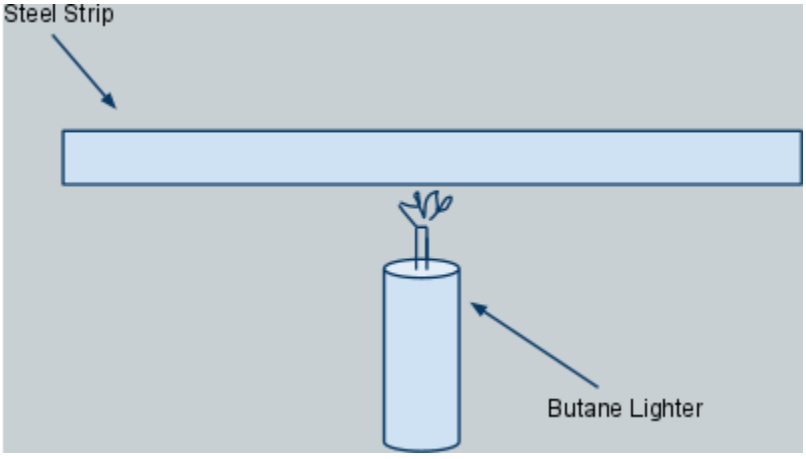
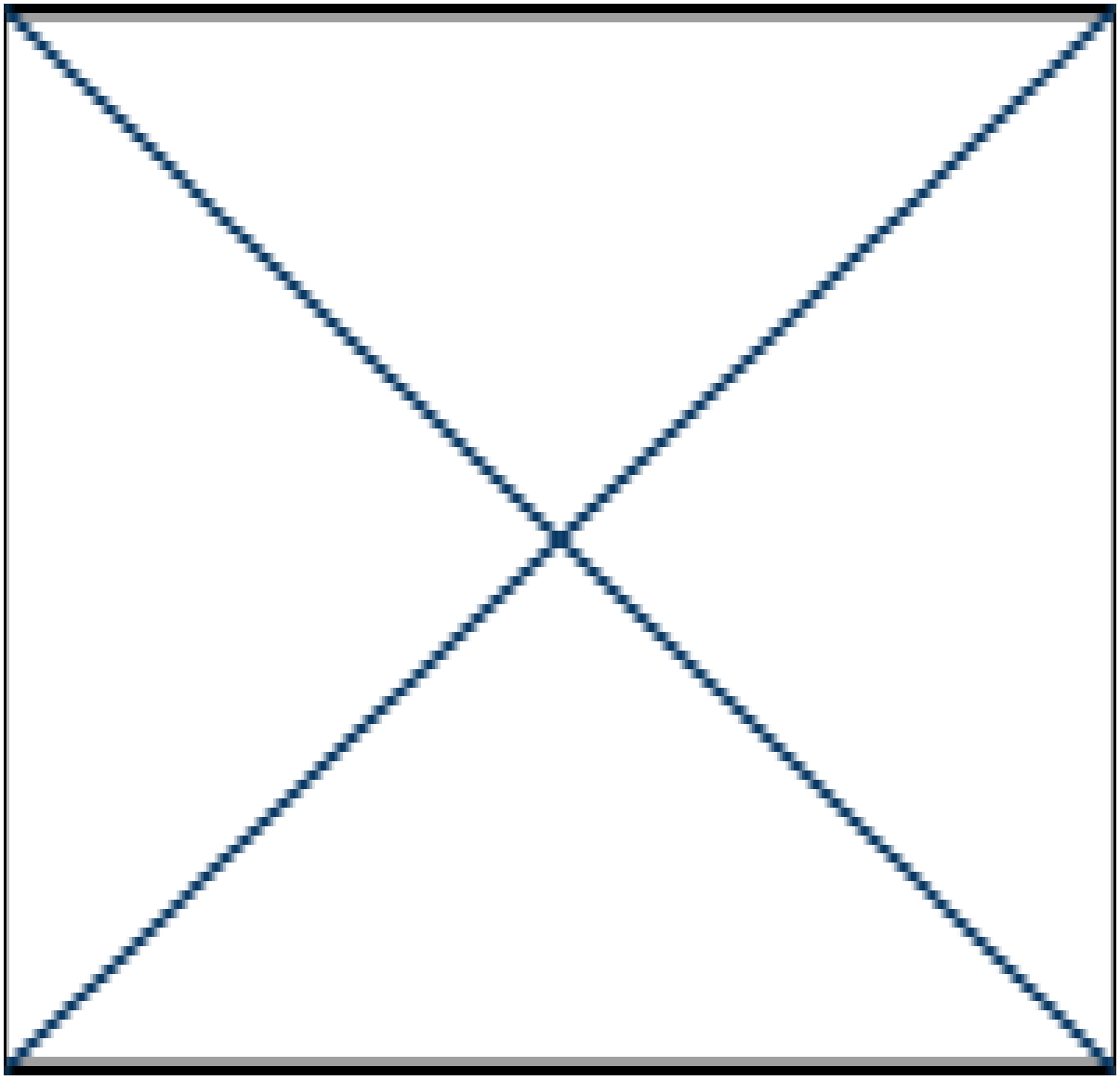


Figure 34**: Solder Iron Plexiglas Bend Method**

Attempt to connect robot to Bluetooth again

At first we were getting a phantom error once we started the game controller. We solved this by connecting using the computer, get the com ports, starting game controller again, and connecting to the robot. It usually takes two tries.



Recorded by: A.F	**Date:** 11.8.09	**Reviewed by:** W.H.	**Date:** 11.9.09

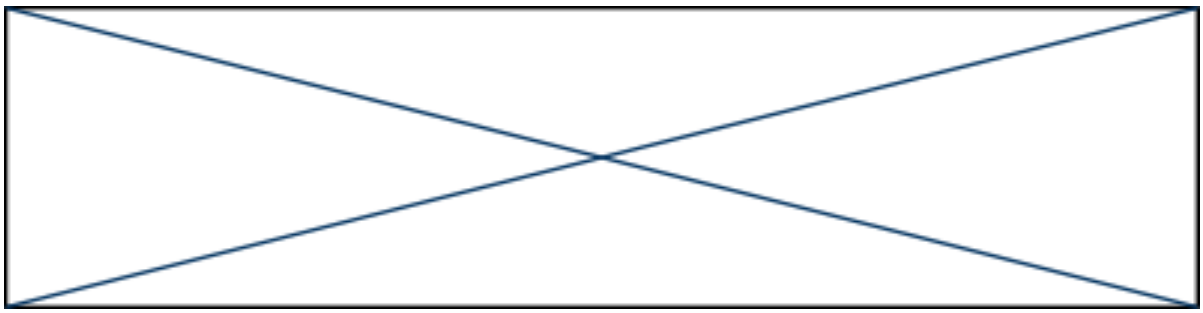
11/9/09

Meeting #13

Task	Reflection
Try to make all motors run at the simultaneously	In the joystick control program, we had left the program on "Modular Robot.C" After we changed it to our "power-train test" program, it worked perfectly.
Tweak ball shooter to make it stronger and to allow the balls to fit through the tires so they will shoot further.	The angle of the ball shooter was changed to allow the balls to roll down the provided ramp and up another to shoot the balls off the robot.
Complete ball collector with the new LEGO parts that arrived.	Collector was completed fully. After a test it all worked great. The balls never go stuck thanks to the flexible rods.
Work on conveyor belt design to lift balls to ball shooter.	The metal Tetrix tubes fit tightly into 1/2'' PVC tubing. We put one in the tube leaving about 1/2'' sticking out to mount a tube clamp on the end to connect a gear.

Try to make all motors run simultaneously

In the joystick control program, we had left the program on "Modular RobotC" After we changed it to our "power-train test" program, it worked perfectly.



11/9/09

Meeting #13 continued

Figure 35**: Incorrect Teleop Setup**

Figure 36**: Correct Teleop Setup**

11/9/09

Meeting #13 continued

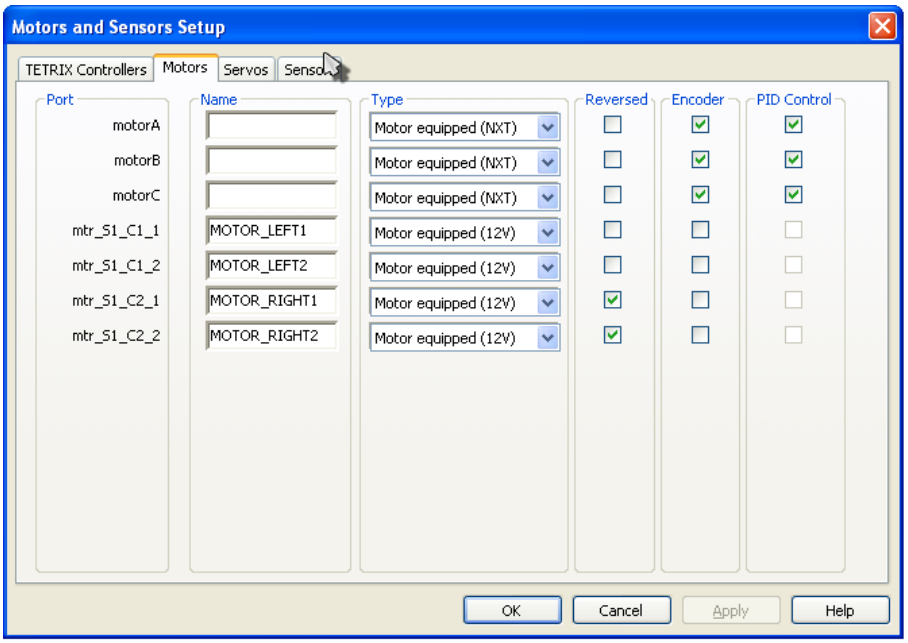


Figure 37**: How Motors Are Setup**

Tweak ball shooter

The ball shooter now has a 90 degree vertical drop. Once the balls fall down there are two bars to direct them to the spinning tires.

Figure 38**: Andrew Working on Ball Shooter**

11/9/09

Meeting #13 continued

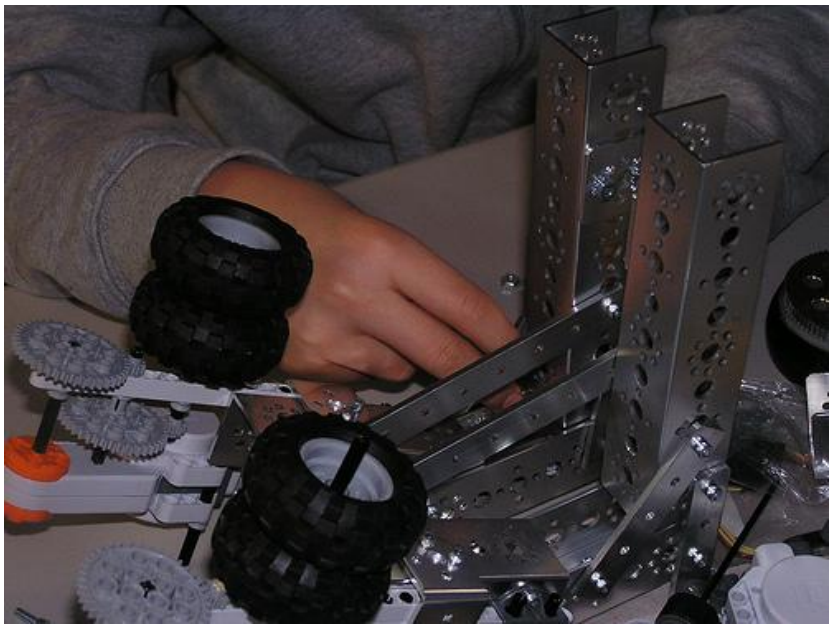


Figure 39**: New Ball Shooter Guiderail Concept**

Complete ball collector

Now fully completed with new LEGO parts. The flexible rods allow for the balls to be released if stuck and for a better hold on the balls when they are coming in.

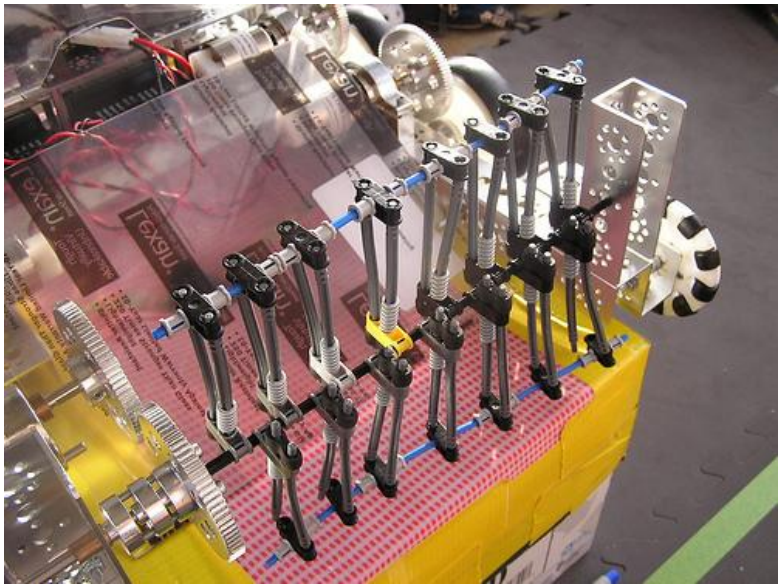


Figure 40**: New Ball Collector with Flexible Rods**

11/9/09

Meeting #13 continued

Figure 41**: New Ball Collector with Flexible Rods (Close-up)**

Work on Conveyor Belt

We took a piece of 1/2'' PVC pipe and press-fit one of the Tetrix tubes in it leaving about 1/2'' sticking out to attach a tube clamp on. We can then connect gears to each end of the pipe and mount them on the chassis. With several of these done acting as pulleys rotating the non-slip pads which will carry the balls up to the shooter.

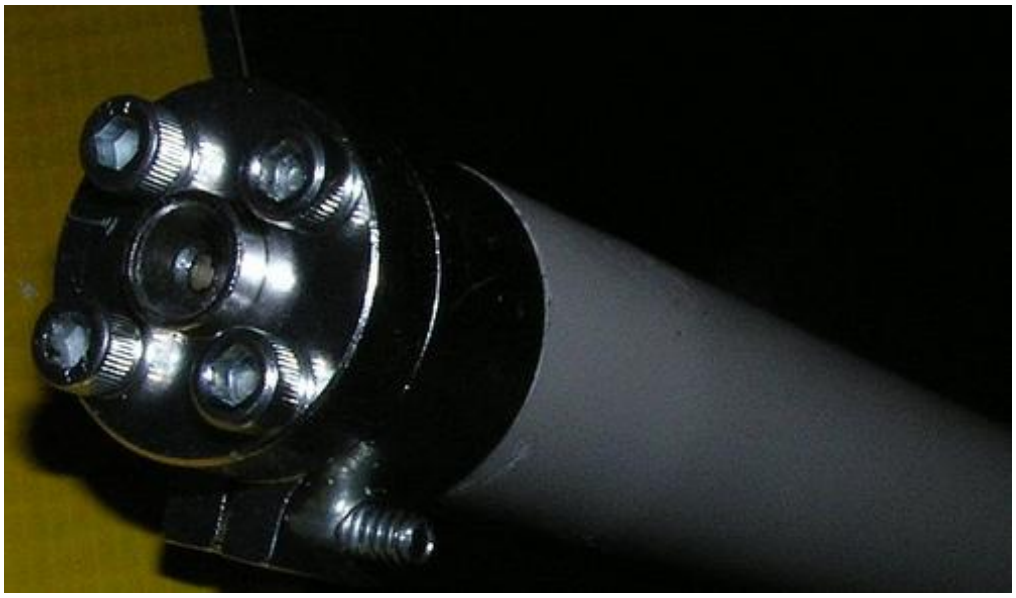


Figure 42**: Conveyor Belt Drive Shaft**

11/9/09

Meeting #13 continued

Figure 43**: Conveyor Belt Drive Shaft (Completed)**

Recorded by: A.F.	**Date:** 11/9/09	**Reviewed by:** N.O.	**Date:** 1/16/10

10/18/09

Meeting #14

Task	Reflection
Begin writing the program to run the ball collector.	The concept was to run the ball collector drive motor at full power from a joystick button push (#4). The motor will be off when the button is released. This would be an initial test, and likely not the final implementation.
Use thread locker to secure all of the nuts and screws on the ball shooter.	The screws on the ball shooting device had become very loose from just working on it so we decided to use Loctite to secure all the screws.
Work on ball conveyor belt.	Ideas for running the conveyor belt were narrowed down to two, and the rotation shaft has been re-designed.

Lock all nuts and screws on ball shooter

Even after vigorous tightening most of the crews and nuts had come loose from the ball shooter. We applied red Loctite to many of the screws to ensure none come un-done.

Figure 44**: Loctite Application**

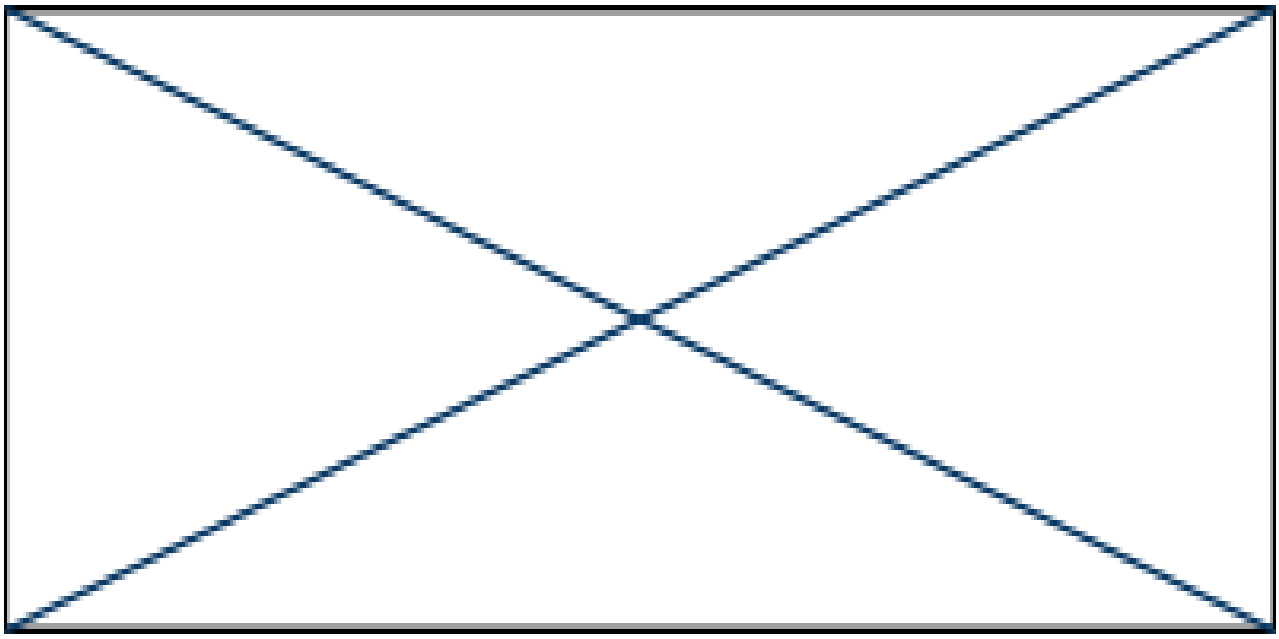
10/18/09

Meeting 14 continued

Work on conveyor belt

We measured the robot to see how long the shafts of the conveyor belt needed to be. Once the shaft was build we put it in place only to find it was too large and that some team members had adjusted the robot without consulting with the group working with the conveyor belt. We had now designed a new shaft without PVC. This will only use the Tetrix tubes and tube clamps. We hope to get to working on this next meeting.

We also got several ideas on how to drive the main shaft for the conveyor belt and narrowed it down to two. We are either going to use a chain and sprocket set or we are going to run it with an already existing motor and gear.



Recorded by: A.F	**Date:** 11.13.09	**Reviewed by:** N.O.	**Date:** 1/16/10

11/15/09

Meeting #15

Task	Reflection
Add side walls to ball shooter and adjust gearing to allow balls to shoot further.	Side wall were added to the device to insure balls don't fall out. The LEGO gear-train was disassembled and is ready for re-building.
Work on ball conveyor belt.	One of the four new shafts was completed.

Ball Shooter

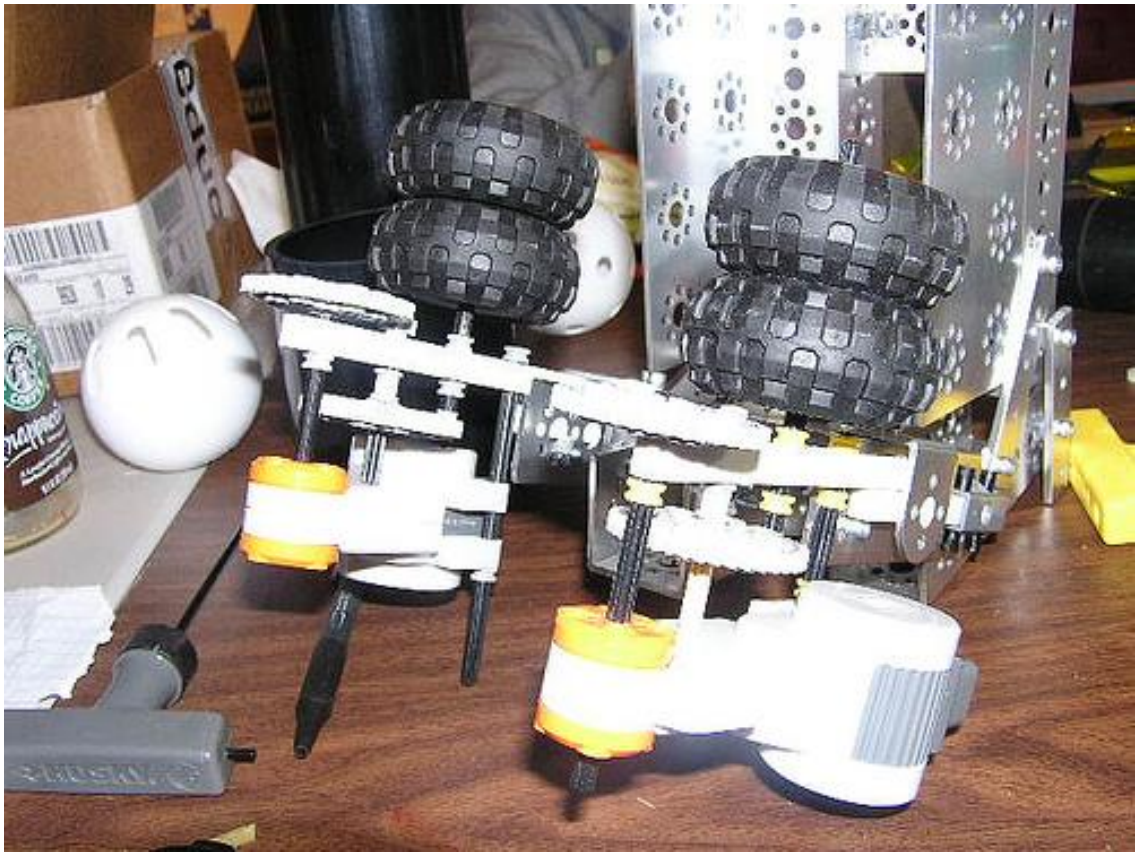


Figure 45**: More Ball Shooter Work**

11/15/09

Meeting 15 continued

The two walls were added to the shooter to insure no balls came out when they fell down onto the device. The balls used to bounce out, but now fortunately don't We also noticed balls bouncing high and loosing momentum so we will have to add a top as well.

The next steps for the ball shooter are to work on the gearing to increase rotation speed, make LEGO attachments less flimsy, and to attach some ABS tubing to the shooter to aim the balls.

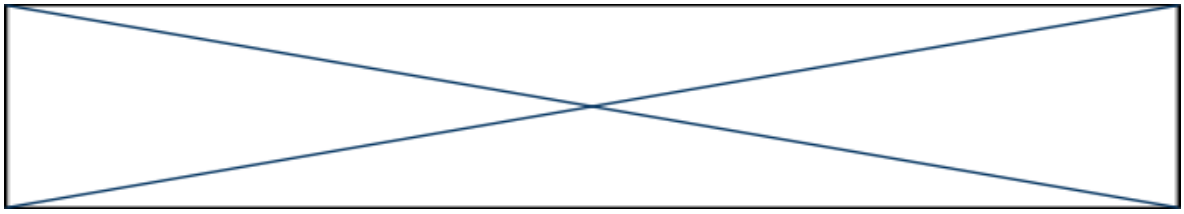
Conveyor Belt

One of the new shafts was build and measured to place on robot. We are still not sure whether we will use a chain and sprocket to run the belt or to run it off existing motors.

Previous shaft

New shorter shaft

Figure 46**: Conveyor Belt Drive Shaft Changes**



Recorded by: A.F	**Date:** 11.15.09	**Reviewed by:** N.O.	**Date:** 1/16/10

11/23/09

Meeting #16

Task	Reflection
Attaching the rotating shaft that rotates the ball transfer mechanism.	We haven't started to work on this yet
Review tasks we need our robot to perform.	We made a table (below).
Work with gearing on ball shooter to increase speed.	We came up with a three layer (6 gears) gear system to replace our older, slower two layer (4 gears) system.

Tasks that our robot needs to perform

Task	What we need to do
The ball shooter needs to shoot the wiffle balls at least 5 feet into goals as well as stay light, small, and fast.	We are now working on increasing the gear ratio so the ball shooter could launch it much farther, at least 2 feet further.
The ball collector needs to be able to pick up multiple balls at a time and rotate when we command it to do so.	The collector is built and running. The shaft and arms are flexible and will bring the balls in like a brush.
The robot needs to be able to drive around.	We have been having problems writing a program but are getting closer.

Ball shooter gearing

From previous tests, a large gear to a small gear will increase speed if you add a *large - small* ratio to another *large - small* ratio, then we should get almost if not double the speed. If we do this three times our result should be a tire spinning nearly three times faster than the NXT motor alone.

large - small gears + *large - small gears* + *large - small gears* = three times the speed of the NXT motor alone, so in theory the ball's distance will increase by 50%.

11/23/09

Meeting 16 continued

Diagram 1

This shows the motor with the 6 gears connected to the spinning tire for the ball shooter.

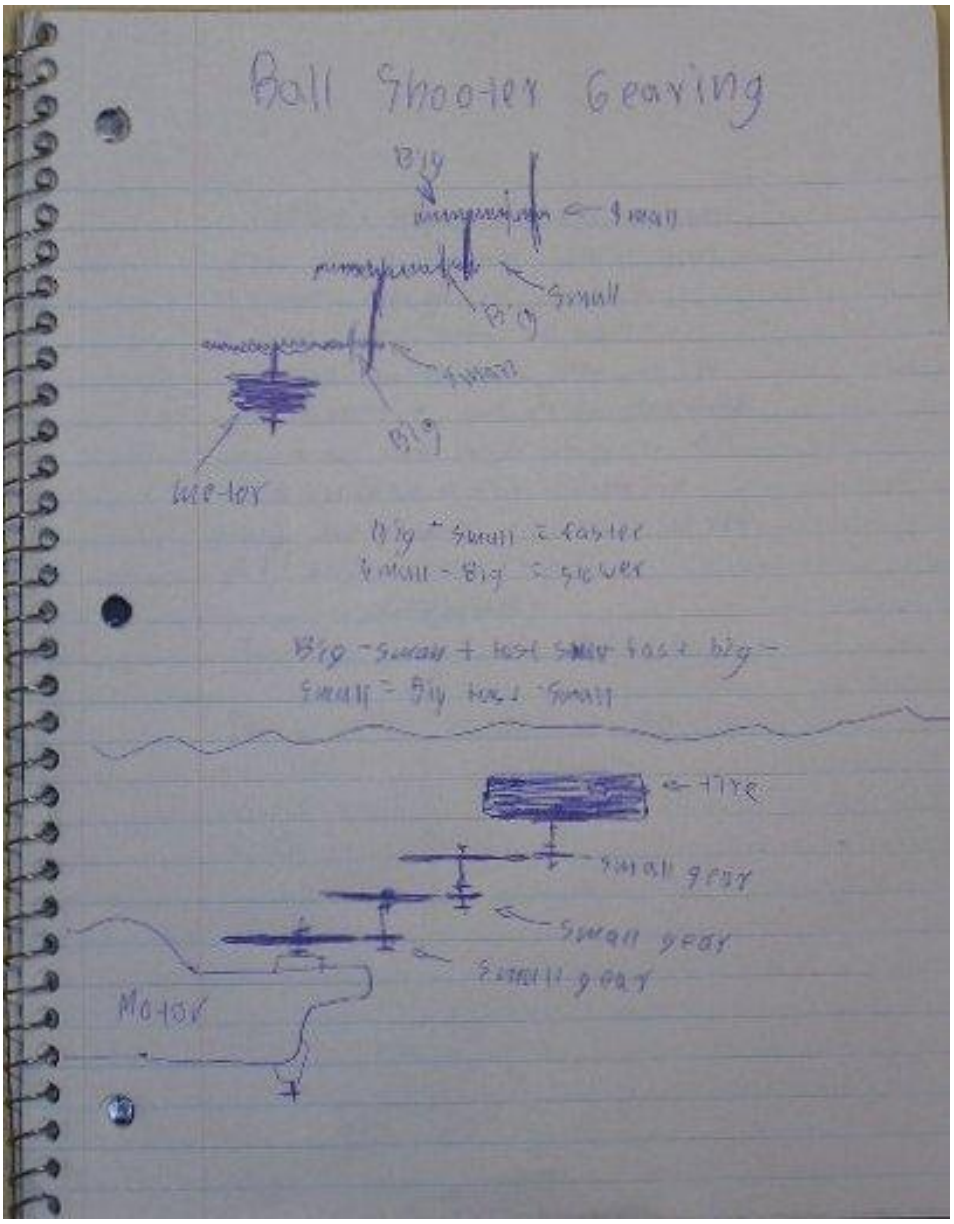


Figure 47**: Ball Shooter Gearing Study**

11/23/09

Meeting 16 continued

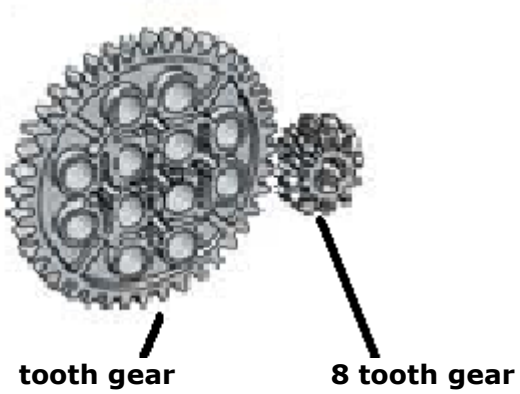


Figure 48**: Ball Shooter Gearing Study 2**

We would like this to be able to fit in a 2'' X 5'' box for the sake of space since we will need two of these.

Robot Chassis and Wiffle Ball Raiser

Drive bar added for the conveyor belt that will raise the wiffle ball into the storage chamber before the ball shooter.

Community Sharing

Ben created a draft of a proposal to send to the Principal of the Elementary schools that the Untitled-8 team intends to share JFLL, FLL, and FTC robotics programs. While there will be a general overview of these robotic programs, specifically it states that we want to emphasize teaching students about FLL and show them the robots we created last year. It also states the things we will require to perform this, including a projector and a fairly large room.

Recorded by: A.F	**Date:** 11.13.09	**Reviewed by:** N.O.	**Date:** 1/16/10

11/27/09

Meeting #17

Task	Reflection
Creating and attaching the 2nd and 3rd part of the Ball Transfer Mechanism.	We have assembled 2 of the shafts of the conveyor belt. We will begin attaching them next meeting. Belt tensioner still needed.
Creating the 2nd version of the Ball Shooter.	After many fits and starts, we are beginning to reassemble onto a metal frame. Previously the multi-gears "up" approached kept jamming or getting stuck because of axle flexing and perhaps` twisting as well. We hope this new approach will resolve some of these previous problems, as the gears are held more solidly in place using the Tetrix given bushings and metal frame pieces.
Find out why keep getting Error 14 message that stops program execution. Note program compiles okay.	We have been stuck on this for two meetings. This meeting however we went back to square one. First we swapped the NXT brick with another and got the same error, so this verified a program issue. Then we tried the original ModularC given test program and this appeared to work. After some scrutiny, it appeared that some curly braces (in the problem drive program), though placed correctly, were unnecessary however. Removal of these solved the problem. We suspect it is a RobotC compiler issue.

11/27/09

Meeting 17 continued

Creating the 2nd version of the Ball Shooter

We really needed more stability and a smoother spin so we used some Tetrix bushings and rods. It had reduced friction greatly and by the looks and feel of it, we should be able to add quite a few more gears successfully.

Here is what we came up with:

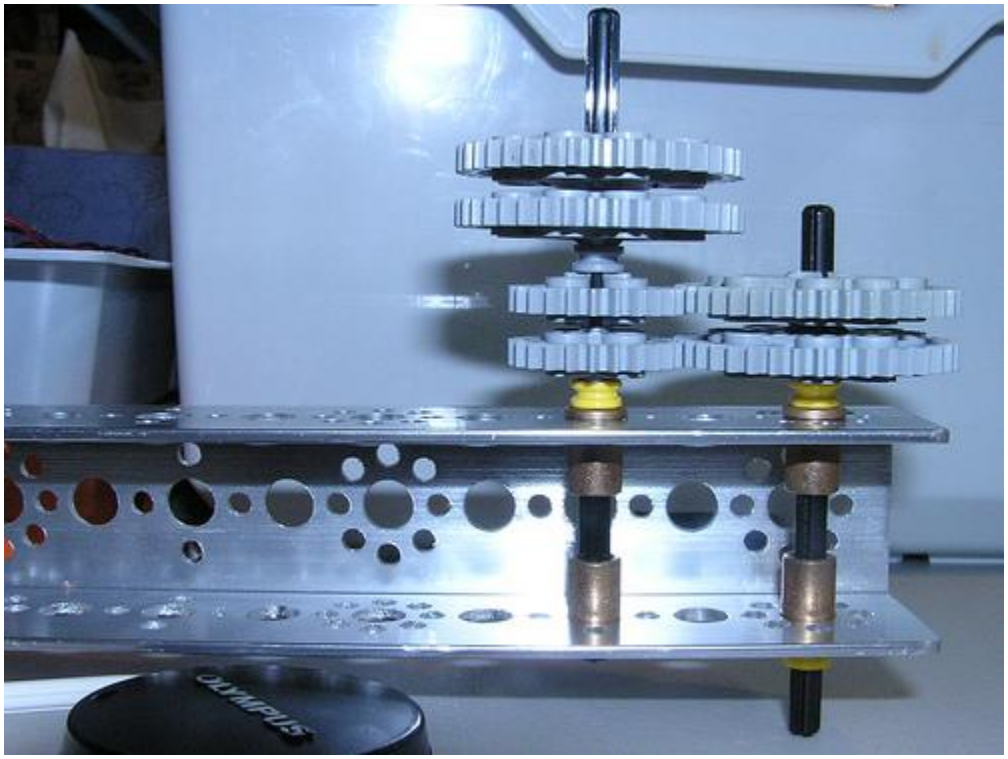


Figure 49**: Ball Shooter Version #2**

A Successful Run at Last!

We are now able to drive the robot, two DC controllers and four motors using the joystick.

Also via separate button push we now (at will) can activate the ball collector.

11/27/09

Meeting 17 continued

We had fun today testing the robot and driving it around to collect balls. It can collect balls even if they are pressed against a wall, and because the ball collector arms are made of soft Lego pieces, it does not jam. And even if pieces break off (which sometimes happen), it still appears to works well.

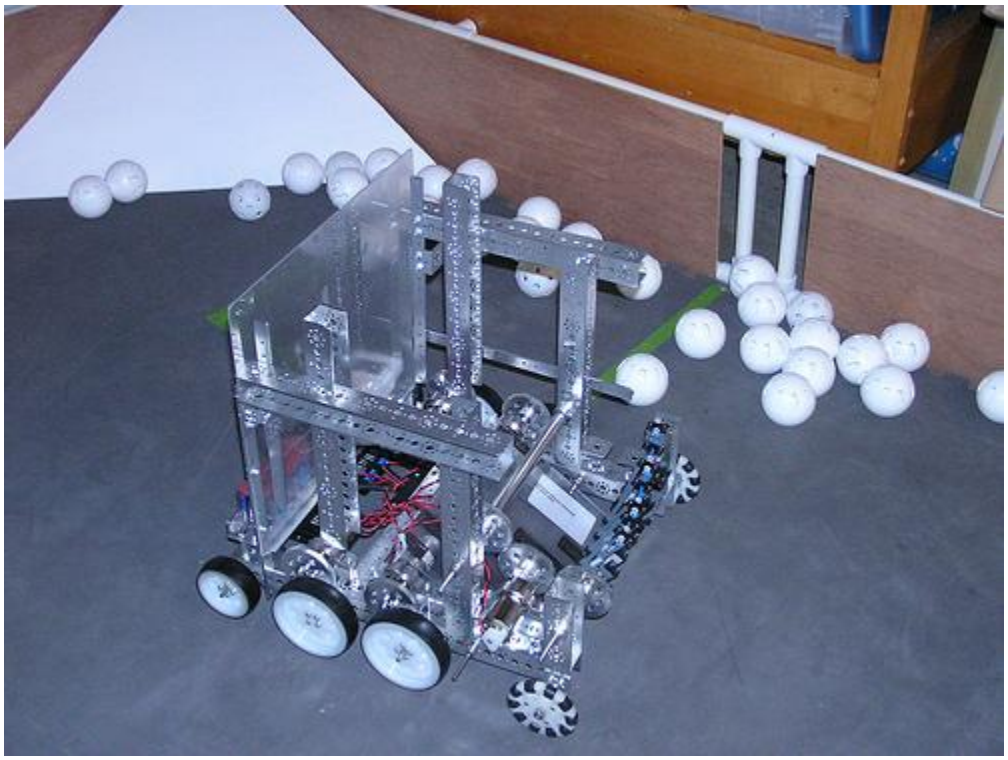


Figure 50**: Drive Testing the Robot**

Recorded by: V.C and S.K	**Date:** 11.27.09	**Reviewed by:** N.O.	**Date:** 1/16/10

11/29/09

Meeting #18

Task	Reflection
Attaching the 2nd and 3rd part of the Ball Transfer Mechanism.	Finished the 2nd part, but we still have to attach the 3rd part onto the robot. We also have the cut the non-slick pad and attach it to the Ball Transfer Mechanism.
Continuing on building the gears for the Ball Shooter.	The most updated version's gear ratio is 1-10, but there is a slight problem. The last small gear stops the rotations.
Creating a table for the Community Sharing.	We finished attaching the hinges to the two wood boards, but there are some screws that are stripped and are tightened diagonally.

Add to Ball Transfer Mechanism

We have two of the three shafts made and in place. Next we have to add the third one and cut the non-slip pad and attach it. The conveyor belt will run off of the existing ball collector motor.

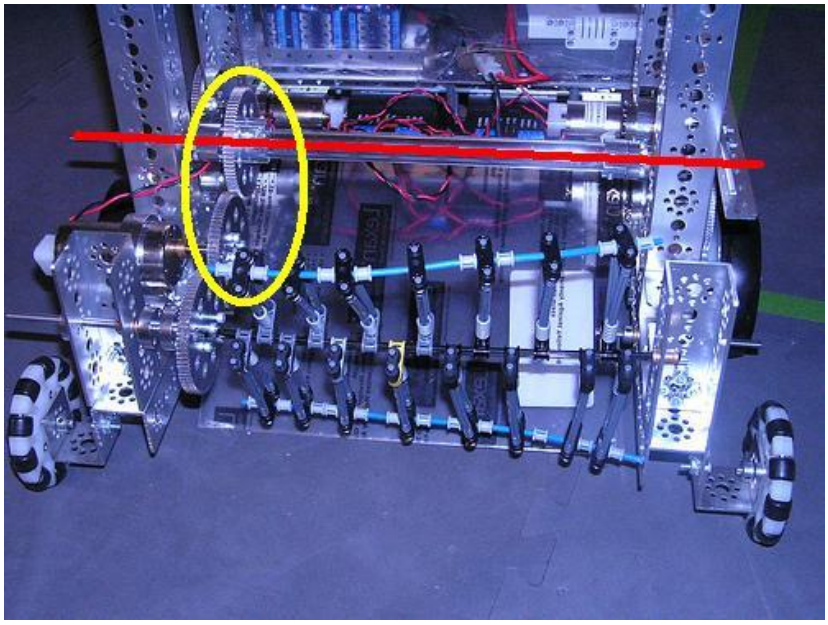


Figure 51**: Ball Collector Improvements**

11/29/09

Meeting 18 continued

Work on Ball Shooter Gearing

So far we have been able to reach a 1:10 ratio, but when a smaller gear is added at the end, thee entire gear-train jams. We are now working on attaching a gear on the side to save room.

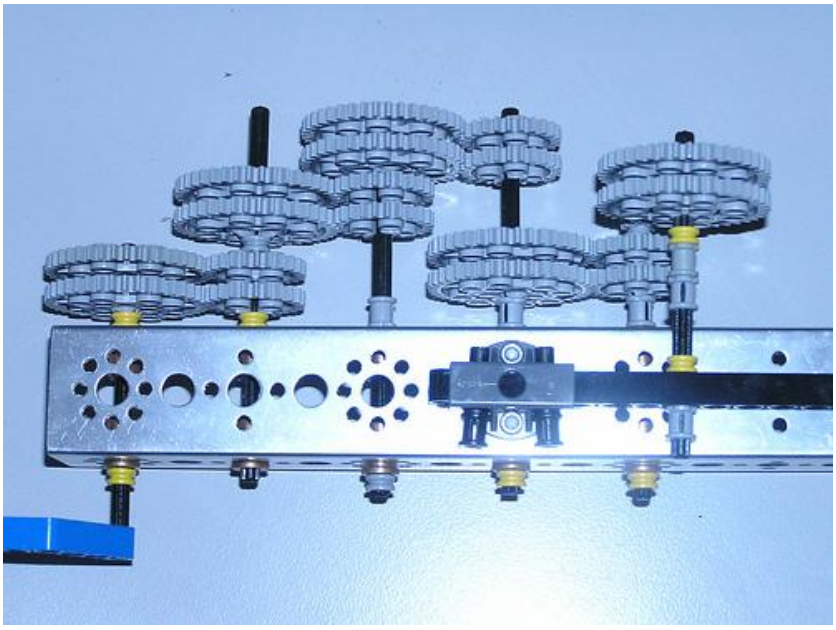


Figure 52**: Ball Shooter Gearing Implementation**

Create Table for Community Sharing

For the community sharing portion of FLL we plan to show kids at a few local elementary schools our FLL robot from last year. We got some wood and but it in half. This is equivalent to one half of a normal FLL table. We plan to make an entire unfold-able table to display the robot off with. We half of two boards connected so far.

We have not decided if we really need two. Will try this first and see how it works out.

Figure 53**: Community Sharing Preparation**

Recorded by: V.C./A.F.	**Date:** 11.29.09	**Reviewed by:** N.O., V.C.	**Date:** 1/16/10

11/30/09

Meeting #19

Task	Reflection
Attaching the 3rd and 4th part of the Ball Transfer Mechanism.	We attached the 3rd part of the Ball Transfer Mechanism to the robot. We still have to attach the 4th part. We also have to measure, cut and attach the non-slick pad to the 1st, 2nd, 3rd, and 4th parts.
Completing the gear attachment to the metal piece and connect the two metal parts together.	We finished gearing up the 1st side, but we ran out of gears to complete the 2nd side. We still have to connect them both and we still have to test the ball shooter.
Making the community sharing table.	We finished painting the side of the table.
Get the ball collector running forward and backward.	We got the motor running foward forever when we pressed button 1, and backwards when we pressed 2. Later the program began to not work at all. We found that we needed to insert "getjoysticksettings" into our sub routines. Also we attempted to make the motor run off of buttons 5 and 6. So far we not been able to make that work. Robot C tells us 5 is called 16, and 6 is called 32. We tried using 16 and 32, that didn't work, and 5 and 6 didn't work ether.

11/30/09

Meeting 19 continued

Ball Shooter

The ball shooter has been causing us some assembly trouble. The gears appear to tend to bind-up and get stuck and refuse to rotate. We have finally finished one side of it; the other is in the building stage. After that we'll have to connect them and attach to the robot. Hopefully things will get figured out along the way.

Figure 54**: Ball Shooter Woes**

11/29/09

Meeting 19 continued

Ball Collector

So far the ball collector part of our program looks like this:

```
getJoystickSettings(joystick);

if (joy2Btn(1) && joy2Btn(2)==0)
motor(BALL_ COLLECTOR) = 100;
if(joy2Btn(2) && joy2Btn (1)==0)
motor(BALL_COLLECTOR) = -100;
if(joy2Btn(1)==0 && joy2Btn(2)==0)
motor(BALL_COLLECTOR) = 0;
```

Figure 55**: Ball Collector Program Excerpt**

This program works so far. The reason that we started having troubles was that the compiler didn't see the "getJoystickSettings" where it was originally. So we moved it to the top of our Ball Collector program. That made it work, but when we tried to replace the ones and twos, it wouldn't run properly and revert back to one and two. This program that we fixed allows us to run the ball collector forward when we press one, and backwards when we press two.

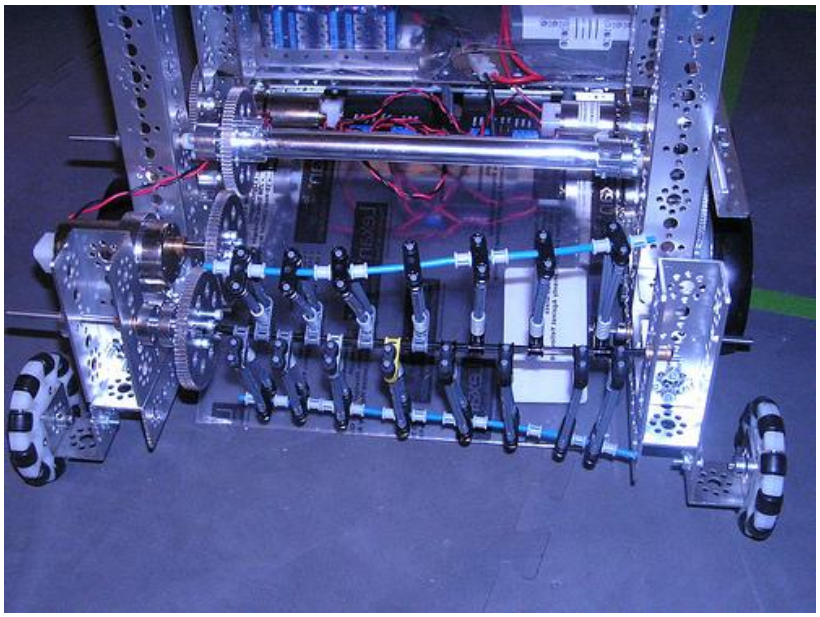


Figure 56**: Ball Collector (Forward/Backward Rotation)**

11/29/09

Meeting 19 continued

Community Sharing Robot Table

Since we are limited on time, we are only going to use the board we have and not use our robot from last year's FLL. The hinge was put on and the one side was painted white. We plan to add a black tape line to have a robot follow it. Perhaps add something else to demonstrate.

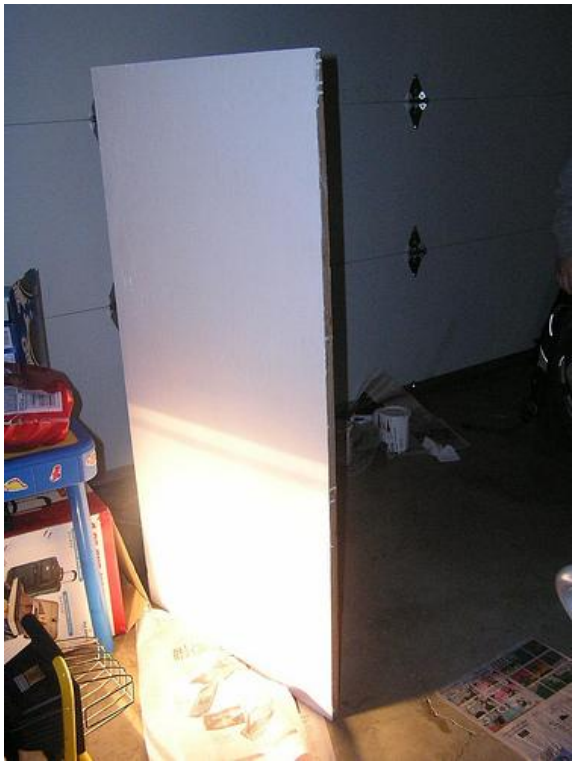


Figure 57**: Community Sharing Robot Platform**

Recorded by: V.C./A.F. and P.S.	**Date:** 11.30.09	**Reviewed by:** N.O.	**Date:** 1/16/10

12/6/09

Meeting #20

Task	Reflection
Build the supporter/attacher for the 4th part of the ball transfer mechanism.	We cut the line on the supporter/attacher part but the bushing wouldn't fit through so we had to trim the line wider.
Program Ball Hunter	We wrote a program on NXT and tried out the robot on our newly-made display table. At first it seemed to work pretty well but sometimes it would go in a random direction
Make Servo Arm	We repaired the servo arm concept, and made a duplicate for the other side of the robot.
Begin Writing Program to Move Servo Arms	Peter began looking at the "Modular Bot" program to see how they wrote the program for servos. Then he inserted the correct programming into "Driver_V8". Also he entered the correct names and values to the servos.
Work on the Gearing for the Ball Shooter	Aaron stopped the gear shooter's wheel vibrating by adding another beam to steady it. He also straightened the crooked NXT motor by using Lego beams and rods to straighten the motor. Still, the motor stuck out from the gearing frame a little bit.

Ball Shooter Gearing

Minimal vibration is taking place. We have completed one side of the device and will now duplicate it to test it. The tire is spinning pretty fast, and would guess we get at least several feet.

12/6/09

Meeting 20 continued

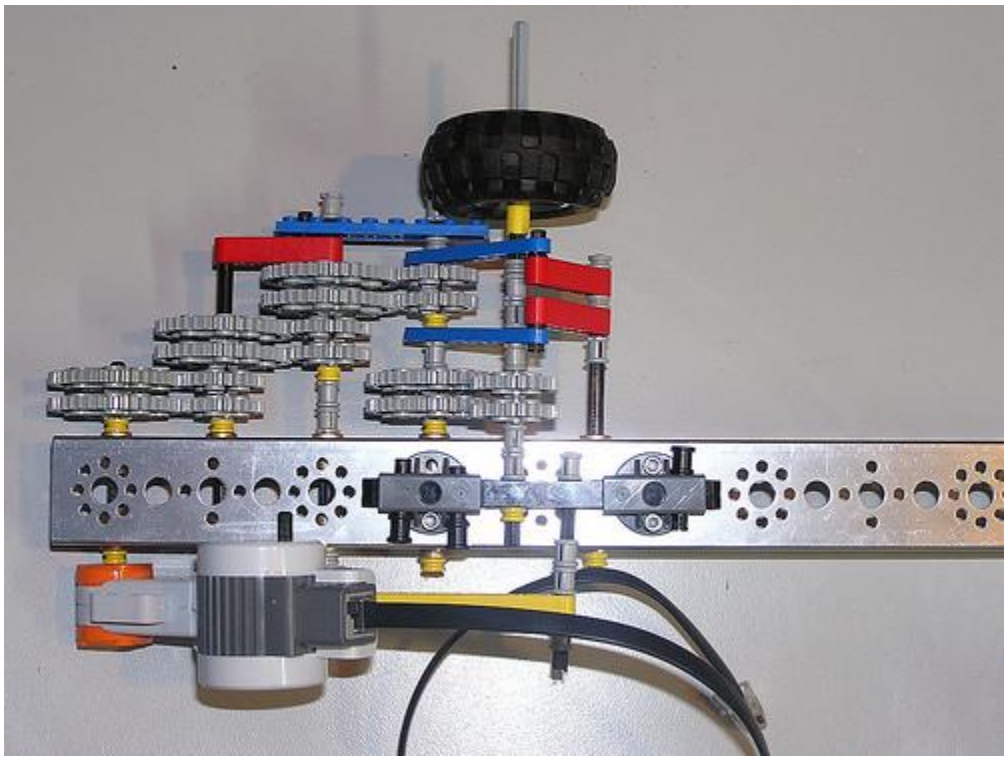
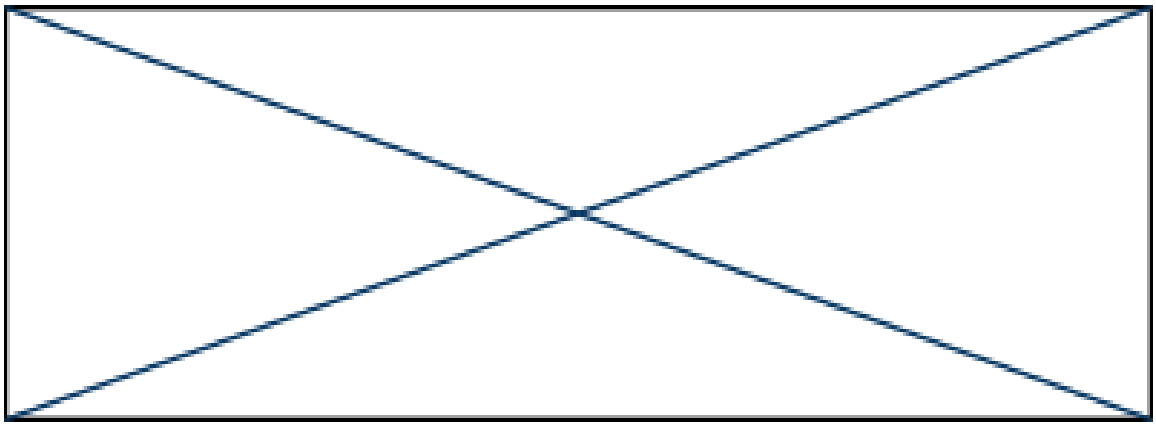


Figure 58**: Community Sharing Robot Platform**

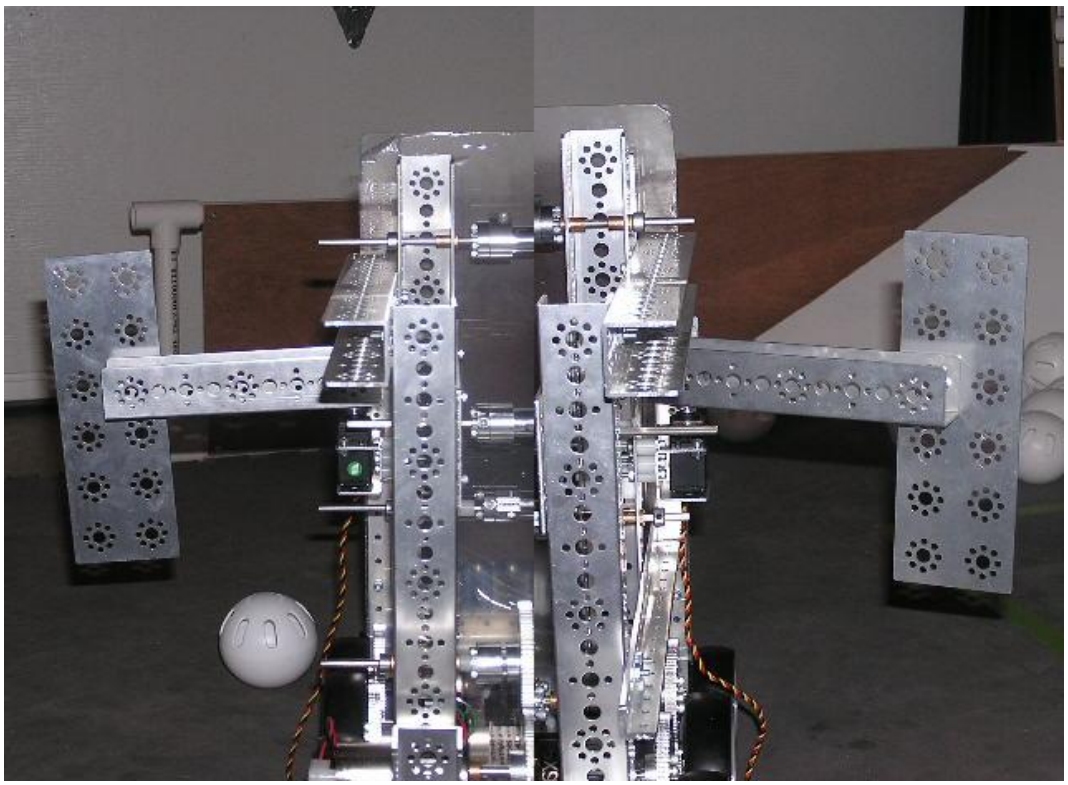
Servo Arm

We added a servo arm to each side of the robot to open the tube ball shuts located at each corner of the field.



12/6/09

Meeting 20 continued



Left Side Right Side

Figure 59**: Servo Arms Concept**

Recorded by: N.O. & V.C. & P.S. & W.H.	**Date:** 12.6.09	**Reviewed by:** N.O.	**Date:** 12/6/10

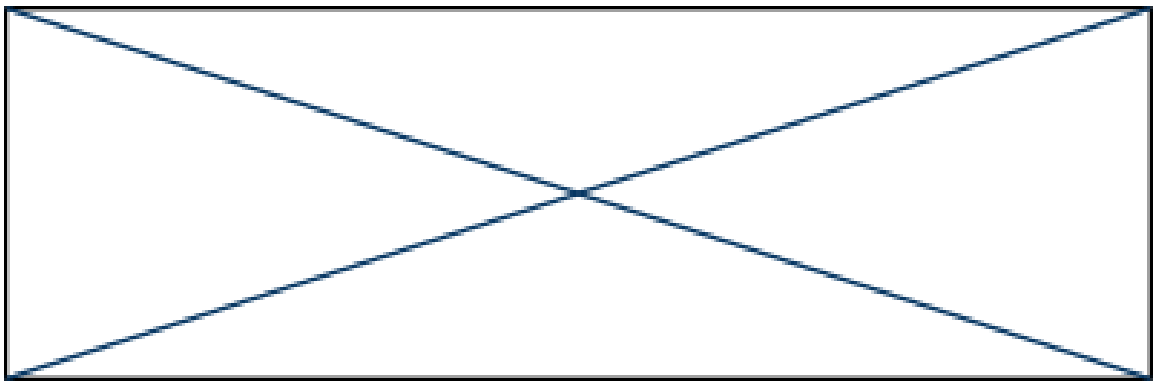
12/7/09

Meeting #21

Task	Reflection
Work on team brochure	We worked well and got a lot done. We added content to several sections of the brochure. We added more details to the mechanical engineering section. We also added more motives to the mechanical section of the brochure.
Constructing the gearing for the ball shooter	We were able to build a design and duplicate it, though we may have to re-gear it because the testing failed.
Attaching the 4th part of the ball Transfer Mechanism, cutting the non-slick pad, and attaching the non-slick pad to the ball Transfer Mechanism.	We finished attaching the parts and ran the ball collector program, which runs the Ball Transfer Mechanism. The Ball Transfer Mechanism works, but we

Ball Shooter

We finally got a ball shooter completed with a complex gear train. It was very large and when it was tested and it didn't work well. The balls didn't go more than few inches and it seemed unreliable. Some new (hopefully final) ideas have been found on YouTube and we are thinking about at new ones.



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Meeting 21 continued

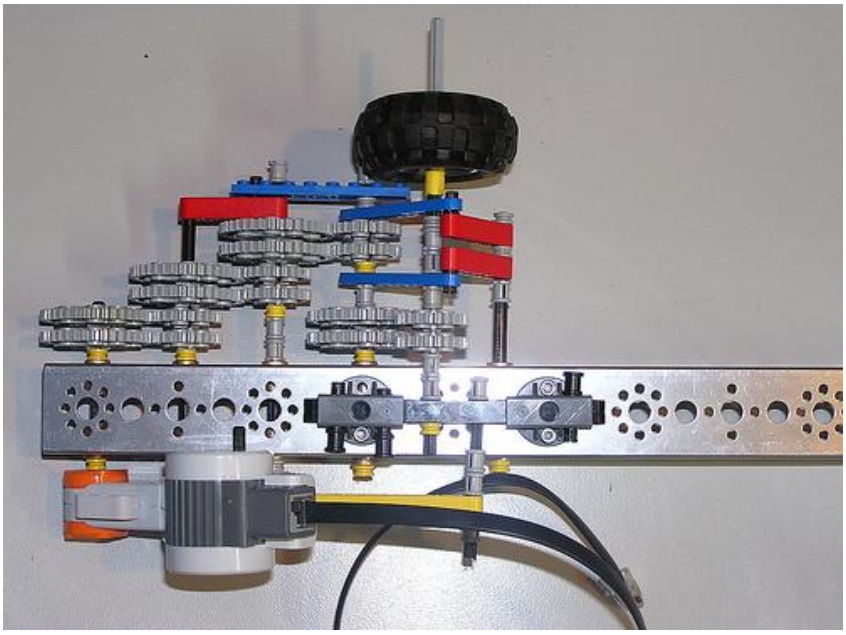


Figure 60**: Ball Shooter Half View**

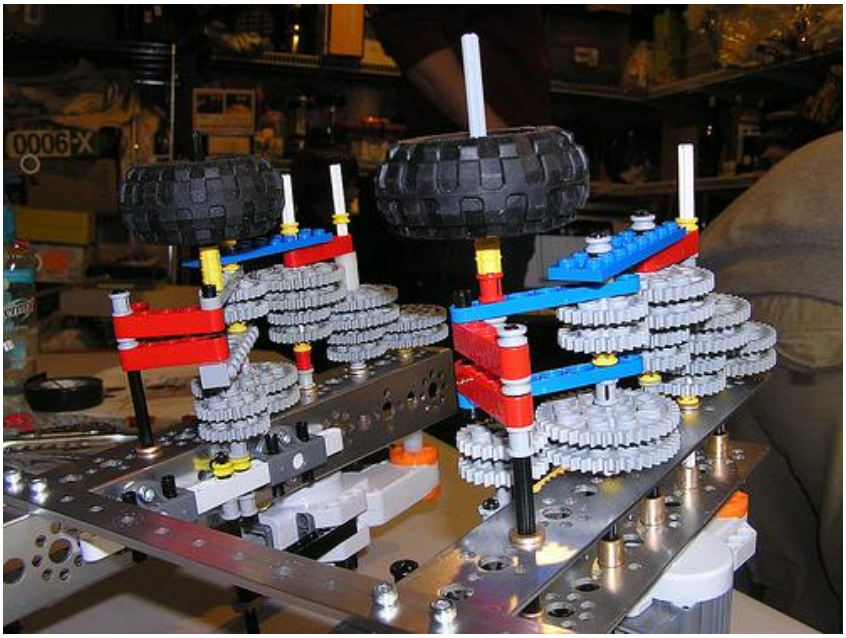


Figure 61**: Ball Shooter Complete View**

12/7/09

Meeting 21 continued

Ball Transfer Mechanism

The non-slip pad was added as well as the fourth and final shaft. It appears to run well and works OK. We may have to change the spacing to carry more balls up at once. At this time the ends are held together with Duct tape (not shown).

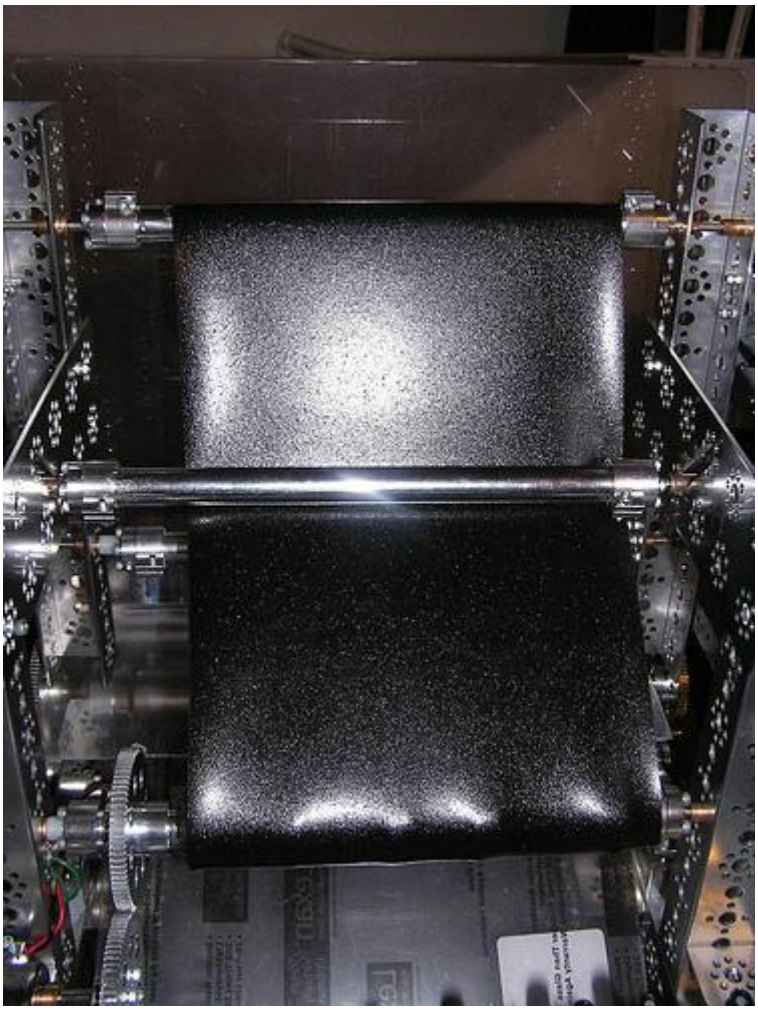


Figure 62**: Ball Transfer Mechanism (Non-Slip Pad Attached)**

Recorded by: V.C/A.F.	**Date:** 12.7.09	**Reviewed by:** N.O.	**Date:** 12/7/09

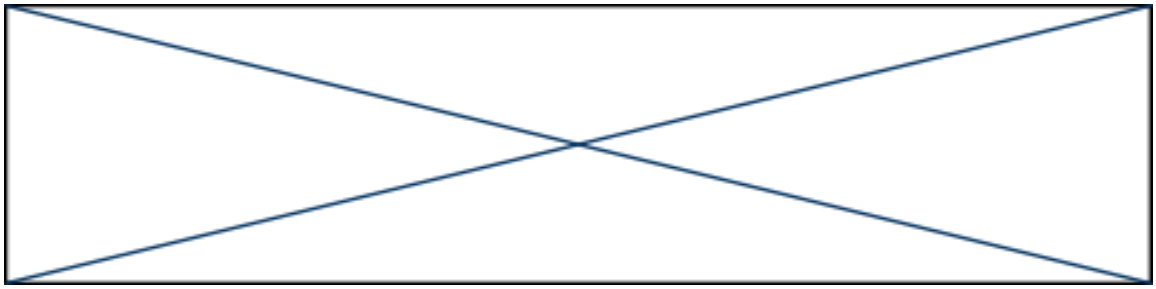
12/11/09

Meeting #22

Task	Reflection
Re-design ball shooter (again)	We recreated the original ball shooter design and started to mount the LEGO apparatus onto two metal bars so that we will be able to mount it onto the robot
Add ramp to robot below the conveyor belt for balls to roll up	The added ramp decreased the space between the wall and belt, so that the ball rolls up more reliably. The back wall still needs to be thickened or moved forward as it is too far away from the belt for a repeatable lifting of the wiffle balls. We might have to add a curve to the bottom corner of the ramp.
Research ball shooter designs online	We found several great helpful videos on YouTube of others robots. It looks like a Tetrix ball shooter geared for speed.

Ball Shooter

We split up and worked on a LEGO ball shooter and a Tetrix one much like the one found online. The Tetrix set-up is very simple and runs off only four gears and is mounted on a single beam.



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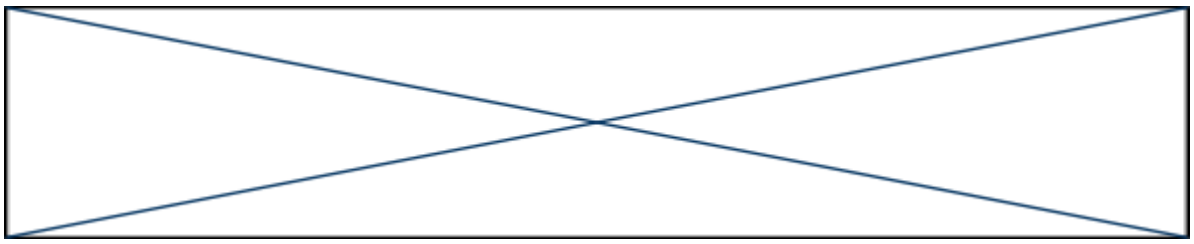
Meeting 22 continued

Figure 63**: Ball Shooter Version 3 (Incomplete)**

Ball Transfer Mechanism

We noticed that the drive belt keeps creeping to the left and right therefore curls up against the mechanism on the side (when runs for a while). Have not thought about this too much just yet however, so no solution yet. We are much more focused now trying the get the underlying foundation of ball delivery assembly in place (the Plexiglas pieces).



Recorded by: V.C.	**Date:** 12.11.09	**Reviewed by:** A.F.	**Date:** 12.19.09

12/14/09

Meeting #23

Task	Reflection
Attaching the conveyor belt together into one piece	We tried to fuse the belt by melting it together with a soldering iron. It worked very well. It is very strong after it cools.
Worked on Tetrix/Lego ball shooter	Now have two sub-teams tackling this task in an attempt to nail this down. One team is exploring a Tetrix motor approach, and the other is re-exploring an NXT motor approach.
Reported RobotC error messages to ORTOP FTC	In the spirit of Gracious Professionalism, sent email to Mr. McBride of ORTOP FTC detailing two RobotC error messages that spell out serious limitations of RobotC, though are relatively easy to workaround. See below for details.

Ball Shooter Status:

Both sub-teams have basic assemblies constructed, but not sufficiently constructed at this point to permit testing; At least another meeting or two away.

Two Designs at the moment are our old Lego one that is small, simple, fast, and a bit unstable. The other would be a larger Tetrix geared shooter what would weight more and be very steady though we may find a decrease in speed.

RobotC Error Details:

RobotC Errors:

1. If you put any device in position four of the chain, the program will delete it from that position. For workaround, see figure below.

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Meeting 23 continued

2. Also, if you put the servo controller into sensor ports 2, 3, or 4, it causes the following error:

> **Error**:Compile time constant array index '65' is outside of array bound '0..23'
>
> Problem & Workaround: The reason that this happens is that the newer version of the program does not account for the newer type of servo controller. At least this appears to be the case. What we found was that you place the Servo controller else were in the port 1 row, and move the extra motor controllers to port 2 row.
>
> The Figure below illustrates the necessary workaround.

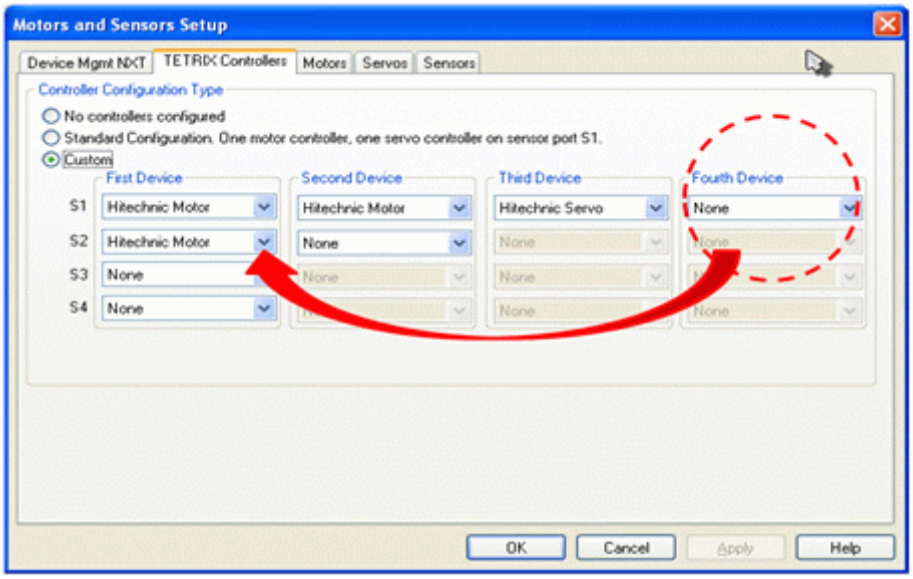
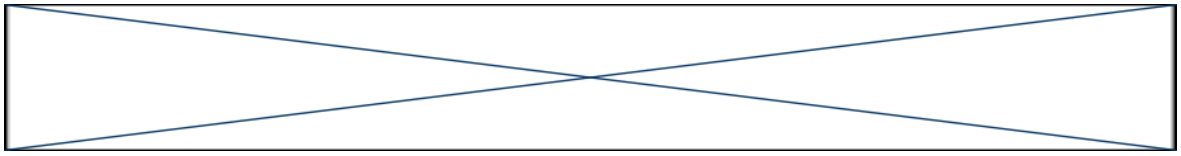


Figure 64**: RobotC Errors and Workaround**



Recorded by: W.H.	**Date:** 12.14.09	**Reviewed by:** A.F.	**Date:** 12.19.09

12/18/09

Meeting #24

Task	Reflection
Work on ball shooter	Continued to look online at other team's designs and adjusted the axle hubs on our current design to allow for smoother rotations. It looks like we are going to put another set of gears below the current one for added speed.
Reformat team brochure	Originally the brochure was created on Microsoft Word. When it was printed several of the pages didn't light up so we're working on copying the information off the Word document and onto Microsoft Publisher.
Sew non-slip pad conveyor belt together	We began sewing the two together with a needle and fishing line. It works very well and needs a lot of power to rip it.

Sew non-slip pad conveyor belt together

After pondering the subject for a while about possible ways to connect the two ends of the non-slip pad together to complete out ball conveyor belt, we began sewing the two together with fishing line. It held well but the ends of the pad ended up ripping so we will need to reinforce that.

Work on ball shooter

Last week the ball shooter was assembled with axle hubs for the motors and not for gears so the mesh was off and causing some issues. This meeting we put the correct hubs on and the gears rotated very smoothly and there was a noticeable gain in speed.

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Meeting 24 continued

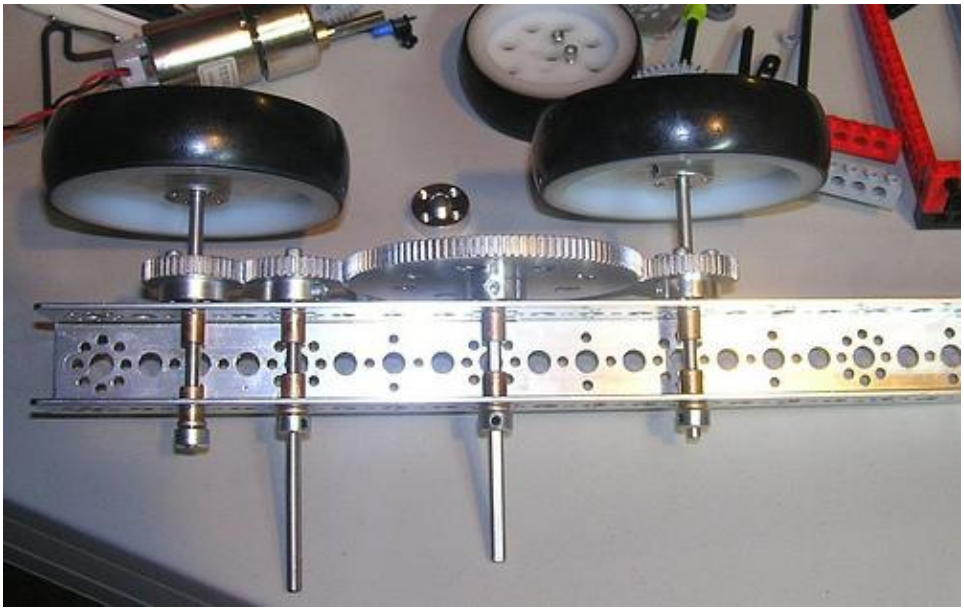

Figure 65**: Our current ball shooter**

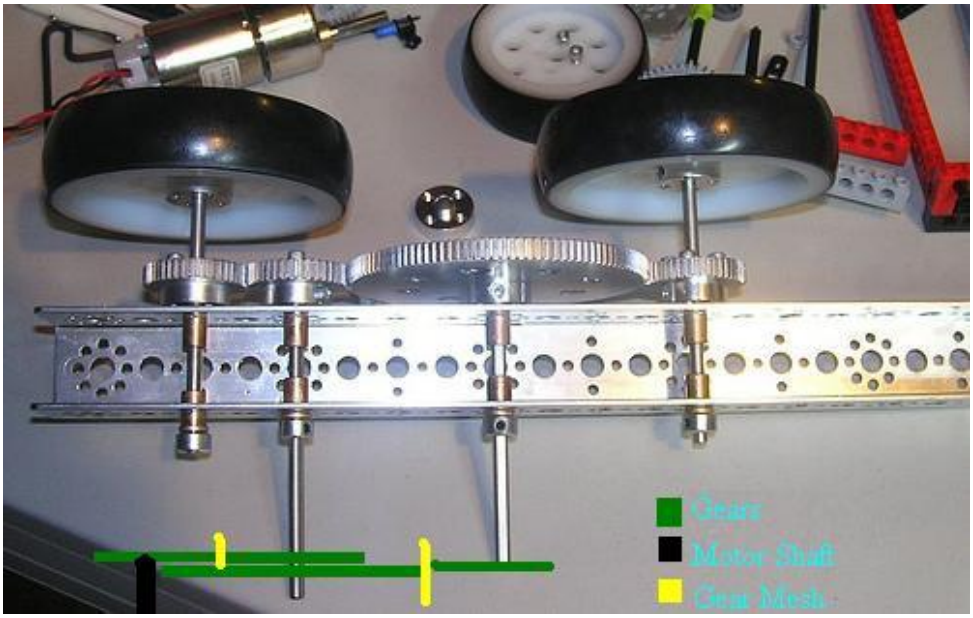

Figure 66**: Ball Shooter Vision (Where we would like it to be)**

Recorded by: A.F. & V.C.	**Date:** 12.18.09	**Reviewed by:** N.O.	**Date:** 1/16/10

12/23/09

Meeting #25

Task	Reflection
Bend Plexiglas to form the back ramp for the conveyor belt	We finished the first version of the Plexiglas back. Once we have the conveyor belt mounted again, we can cut off the parts we don't need.
Replace drive bar for conveyor belt to prevent belt creep.	We believe the problem was the irregular tires used to create friction between the drive bar and belt. Because of their irregular angles and the warping caused by tension, the belt would creep over to the drive gear or the opposite wall, and could catch on something or get stuck between the gears, which would both jam and rip apart the conveyor belt. Replacing the metal bar with a PVC pipe seemed to create more friction, and the PVC can be sanded for a rough surface with more friction.
Create working ball shooter and mount.	Using a Tetrix motor and gears, we geared our ball shooter high enough for it to shoot wiffle balls a sufficient distance to score. We added several layers of non-slip pad around each of the small tires. This design was successfully.

Plexiglas

We began our task by measuring the dimensions that we needed to cut the Plexiglas. The dimensions were 13in.x18in. Then we used the table saw to cut the Plexiglas down to size. Once that was done we

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Meeting 24 continued

took the left over pieces and tested our method of bending the Plexiglas. Our method was putting the Plexiglas over a broom stick, then we heated the Plexiglas along the line with a propane torch. We found that the broom stick didn't give us the right angle. So we took a packaging tube, wrapped it in aluminum foil, and then tested what angle it gave us. The packaging tube gave us the right angle, so we moved to the real piece of Plexiglas we measured for placement on the robot. After the first try we found we needed to bend it even more, so we heated the plastic in front of the old bend, the weight of the glass helped to bend it to the right angle. Once the conveyor belt is placed back on, we will mount the Plexiglas to see if we need to cut any pieces off.

Ball Shooter

After many tries at the ball shooter, we finally found one that works. It's fairly large and heavy, but the weight may not be a bad thing. It more evenly distributes all of the weight around the robot which helps keep it balanced.

The ball shooter consists of a 27::1 gear ratio.

Big to small > Big to small > Big to small

We started the meeting off testing the shooter with the larger of the two Tetrix wheels. The void between the tires was too small for the balls. Next, we tried the smaller tires and the void was too large. Since the there was nothing we could take off the large wheels to make them work, we were stuck with the smaller ones. We had to add something too them to increase the diameter. The two ideas brainstormed were rubber bands and/or non-slip pad. We didn't have adequate rubber bands, so the non-slip pad was chosen.

The pad was cut into thin (3/4'') strips about 9'' in length. We wrapped as many as we needed around each tire and found that nine layers did the trick. Out first idea was to tape them one even though tape was not allowed. We would use this as a temporary solution. It was all set-up and we connected the red end of the wire to the red cable on the battery, and same with the black. The device was obviously extremely

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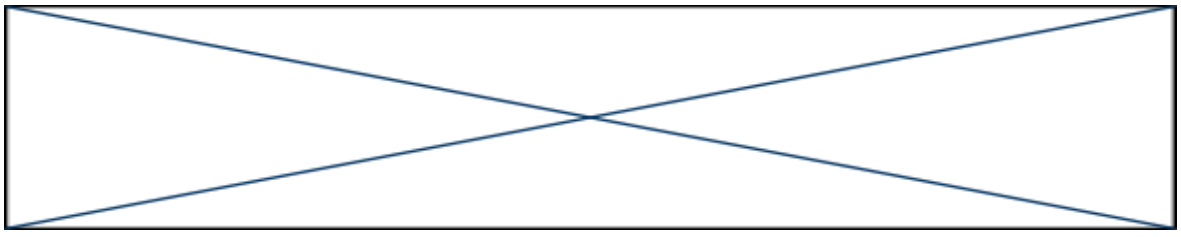
Meeting 25 continued

powerful and fast. It ripped the entire non-slip pad off. It had to be fixed so we found some legal string to tie around the tires and weave through the holes in the wheel. This worked really well. The balls shot at least 7 feet across the garage.

Since the material on the tires was not being held on by much, the whole set-up was disassembled and new longer pieces began mounted on the tires. So far we are only on the first one, though are confident that this will be the way to go.

Figure 67**: Ball shooter Version #3, Test #1**



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Meeting 25 continued

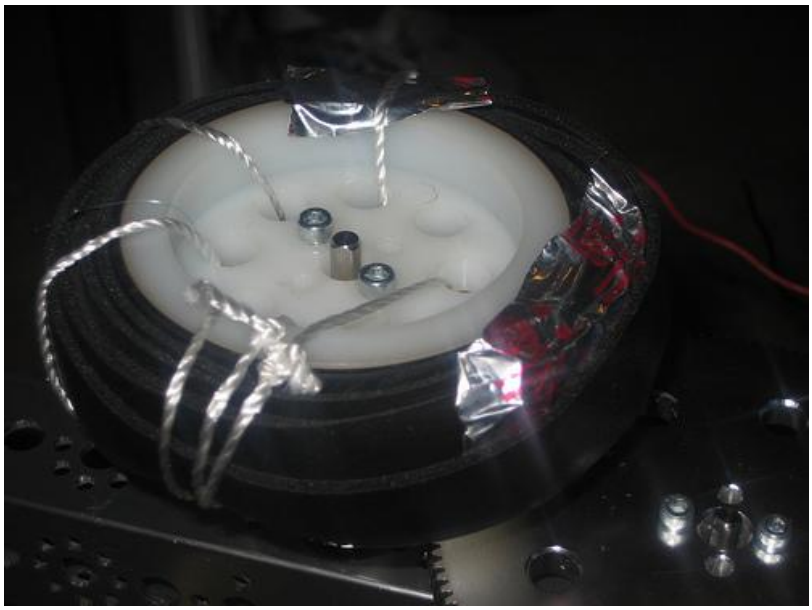
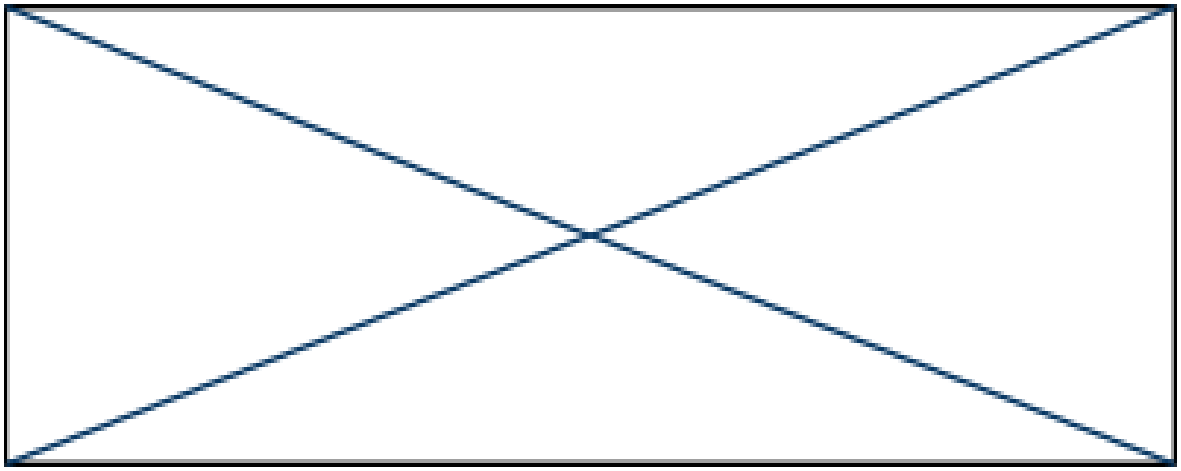


Figure 68**: Close-up of tire with non-slip pad on the shooter**

Needless to say we are very happy. We finally have a ball shooter that appears to work, and works well. We had a lot of fun testing and playing with it.



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Meeting 25 continued

Figure 69**: Ball shooter in-action**

Figure 70**: Ball shooter tire getting its finishing touches**

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Meeting 25 continued

To mount the ball shooter on the front of the robot, we move the drive motor on the shooter to the rear of the device and screwed it on offset in front of the main robot sides. It is directly above the ball collector, and very close to the ball shooter.

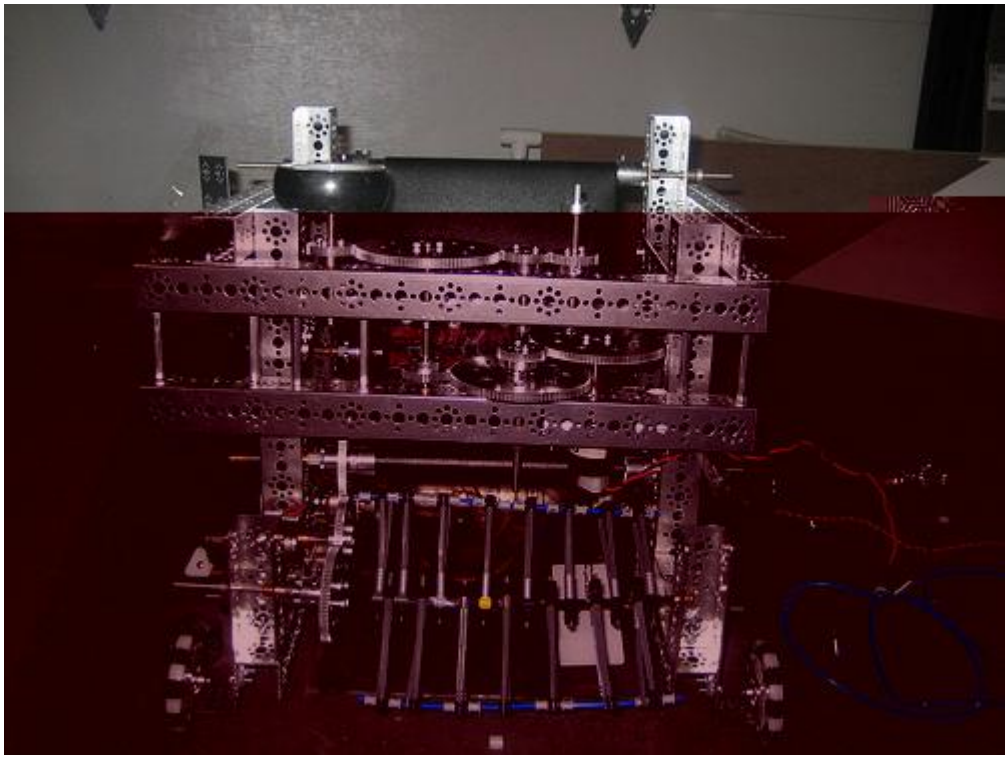

Figure 71**: Ball shooter mounted temporarily on robot**

Recorded by: P.S./A.F./S.K.	**Date:** 12.23.09	**Reviewed by:** N.O.	**Date:** 1/16/10

12/27/09

Meeting #26

Task	Reflection
Upgrade FTC RobotC and latest FCS	Referenced FTC email blast links and downloaded and installed.
Look into HiTechnic IR sensor usage requirements	Located sample program and drivers on HiTechnic website. Believe drivers are part of RobotC install so that should be fine (we'll see). More interested in sample program so can jumpstart code writing for autonomous mode.
Attach Belt	Used plastic coated rope purchased from Dick's Sporting goods store. This was a very thin diameter. The smallest diameter plastic coated rope from Home Depot appeared quite large 1/16 inch or 0.0625 inch. The Home Depot rope was twice the legal limit of 0.03125. See further notes below.
Servo mounting	The servo on the left side of the robot is backwards, so it had to be mounted opposite of the one on the right. Our servos have identical turning radii, so the servo thought that the home position was directly behind it. We had to mount the servo upside down to correct this.

Belt Attachment

We added a second strip of belt for strength so the wire rope would not cut through the belt, and used a piece of masking tape to temporarily hold the belt in place while we sewed it. The tape will carefully be torn off. See picture below.

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Meeting 26 continued

Figure 72**: Belt Assembly (with Plastic Coated Rope)**

Then we traced the plastic coated rope back through for additional lateral strength, and (hopefully) to keep the stitches from pulling through. The two ends were tied together. All in all we used about 15 inches of plastic coated rope. See below:

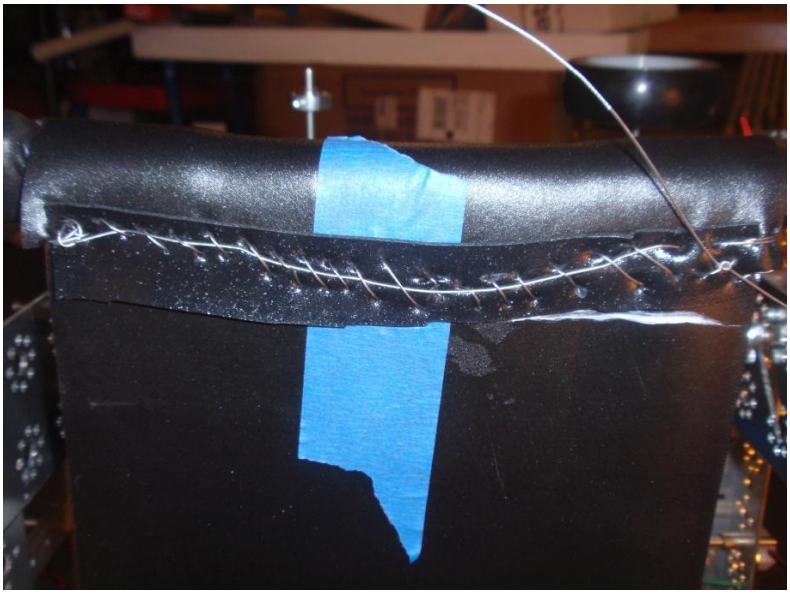


Figure 73**: Belt Assembly Complete**

12/27/09

Meeting 26 continued

Servo Mounting

Right side servo motor, mounted correctly, right side up.

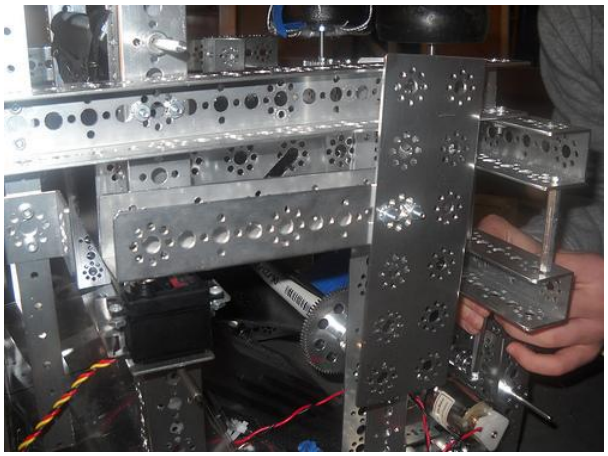


Figure 74**: Right Side Servo Mounting**

Left side servo, was mounted upside down, to make sure that the home position was in front of the robot.

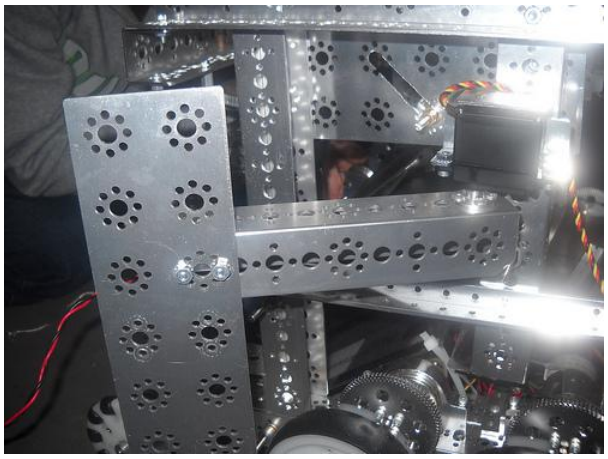


Figure 75**: Left Side Servo Mounting**

Recorded by: W.H.	**Date:**12.27.09	**Reviewed by:** A.F	**Date:** 1.3.10

1/3/10

Meeting #27

Task	Reflection
Attaching the curved back plate to the back of the robot.	We cut a tube of ABS in half, then trimmed it down. We haven't mounted it to the robot yet, but we will soon.
Write up a safety protocol for the team to post on the website and the forum.	Peter wrote up the protocols and Aaron helped him post them online. Then he sent it to the FTC forum, Mr. McBride, Cathy Swider, and Ian McBride
Using plastic covered rope to tighten the non-slick pad to the wheel.	We tightened the non-slick pad to both of the wheels with plastic covered rope. It stays on very tightly and is very strong. We tested it out and the non-slick pad does not slip out.
Reply to Mr. McBrides email about the problems with adding controllers in RobotC	Mr. McBride responded to Peter's email about the problem with adding controllers in RobotC, and Peter thanked him for what he did.
Post Question on Forum about the values of buttons in RobotC, and figure out how to use buttons in RobotC code.	Peter created a profile on the RobotC Forum. Then he asked our question. We wanted to know what we had to define the buttons as in RobotC. From the earlier version, we learned that the buttons aren't defined as what number they are. For example, 4 is defined as 16. Peter found in the "Help" section how we set up the code.

1/3/09

Meeting 27 continued

Safety Protocols

Today Peter wrote some official safety protocols for the team. Then he sent them out to Mr. McBride, Cathy Swider, and ORTOP. The safety protocols are that team members wear safety goggles when debris could get in their eyes. When team members are working with items that produce noxious fumes, they wear painting masks. Our biggest protocol is that no one goes near the robot when the main power is on, we do this because we don't want people to get their fingers caught in the gears.

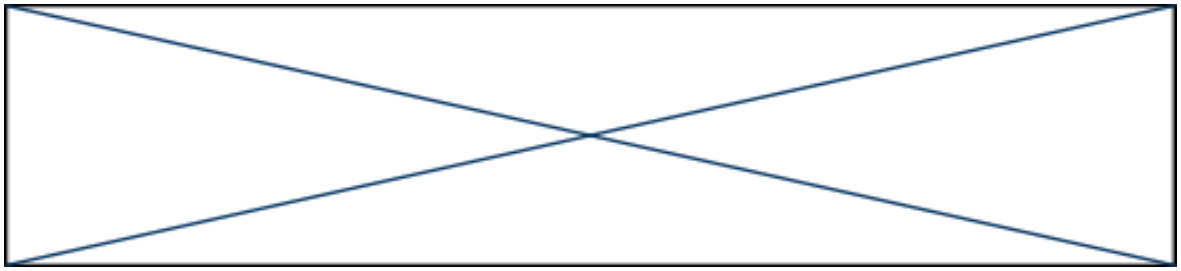
Safety Protocols:

1. When team members are working with something that could damage their eyes, we wear safety glasses. Each team member has their own pair.
2. If team members are working around nauseous fumes or something that could get in their mouths or noses, they wear dust masks. Note: sometimes fumes are given off when we cut plastics (ABS, Plexiglas, Lexan, etc.), so we always wear masks then as well.
3. Our biggest protocol is that when the main power for the robot is on, no one touches it. We are very concerned about a finger getting caught in the gears.
4. We also made it mandatory to place safety shields (where possible) around gears to make sure that fingers or clothes don't get caught.

Figure 76**: Safety Protocols**

Ball Shooter

The ball shooter wheels were completed and tested. It worked perfectly and launched the balls across the garage.



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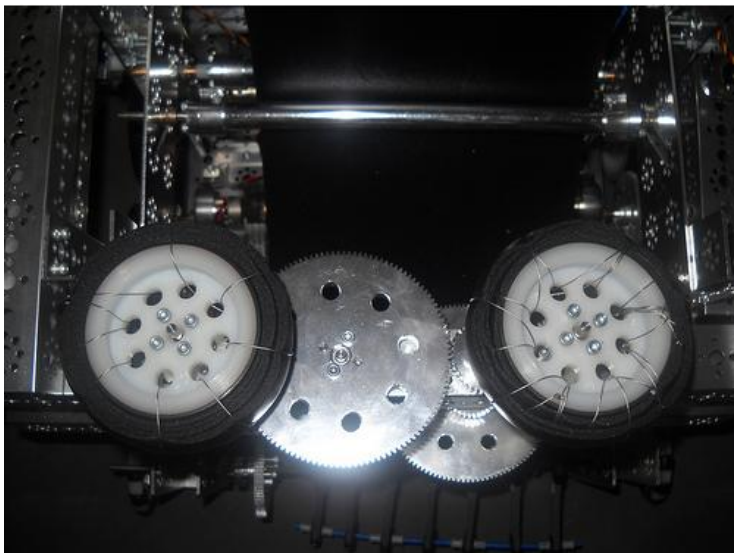


Figure 77**: Ball Shooter Complete**

After the twine we previously used repeatedly slipped apart, we tried very thin plastic coated robe. This was small and out stayed tied.

Figure 78**: Ball Shooter Updated (Plastic Coated Rope)**

1/3/09

Meeting 27 continued

Wren figured out a way to make it so the bottom of the ball shooter was sticking out on the bottom and made the ball shoot up.

Figure 79**: Wren Working on Ball Shooter**

Under the rotating tires put down will be a section of an ABS tube for the balls to roll up and out smoothly without hitting the gears below.

Figure 80**: Ball Shooter Aim Jig Concept**

Recorded by: V.C./A.F.	**Date:** 1/3/10	**Reviewed by:** N.O.	**Date:** 1/16/10

1/4/10

Meeting #28

Task	Reflection
Making the sloped Plexiglas for the ball shooter	We made and mounted a tray that gravity-feeds balls from the the top of the conveyor belt to the ball shooter at a downward incline of approximately 13 degrees. However, we have not tested the tray yet.
Making a new curved Plexiglas for the back of the robot. (Ball Transfer Mechanism).	We made the curve less sharp. The curve is more of a ball shaped curve.
Check Forum and see if we can begin writing new code, using the information from the Forum.	Peter checked the Forum to see if any one had responded to his post.
Begin Writing Autonomous Program	Peter started to look at how to write the autonomous program, and began to write a sample.

Forum

Peter checked the Forum for a response. There was one, but unfortunately the response didn't help. So Peter thanked the person for his response, and posted a new request on a different page. Then using what we remembered, Peter began writing a code to run the ball shooter. He used the information that he found under "Help" to write a program using more than just the 1 and 2 buttons. Now when we press button 5 the ball shooter will spin at 25% power.

Autonomous

Peter started to write our autonomous program. He inserted the information we needed to initialize the robot. Now when we start autonomous the program will return our servo arms to home. We still have to test this program to see if the arms will move to home. Also Peter defined all our motors and sensors for the program.

Recorded by: V.C. A.L.	**Date:** 1.4.09	**Reviewed by:** N.O.	**Date:** 1/16/10

1/8/10

Meeting #29

Task	Reflection
Mount strip of plastic to back plastic sheet to allow balls to roll up without stopping.	Every part is glued into place, waiting for the glue to cure for 12 hours
Adjust ball ramp and mount.	We ended up making some minor changes to the ramp. First, we made the bent angle small, and then we warped the inside for a channel for the balls to roll down directly to the ball shooter.

Mount plastic to back plate

Under the conveyor belt and on the back of the robot we mounted a piece of plastic in the bend. The bend original made was too tight, so the balls wouldn't get enough traction to roll up the back. We used silicone sealant, and so far it seems to be working.

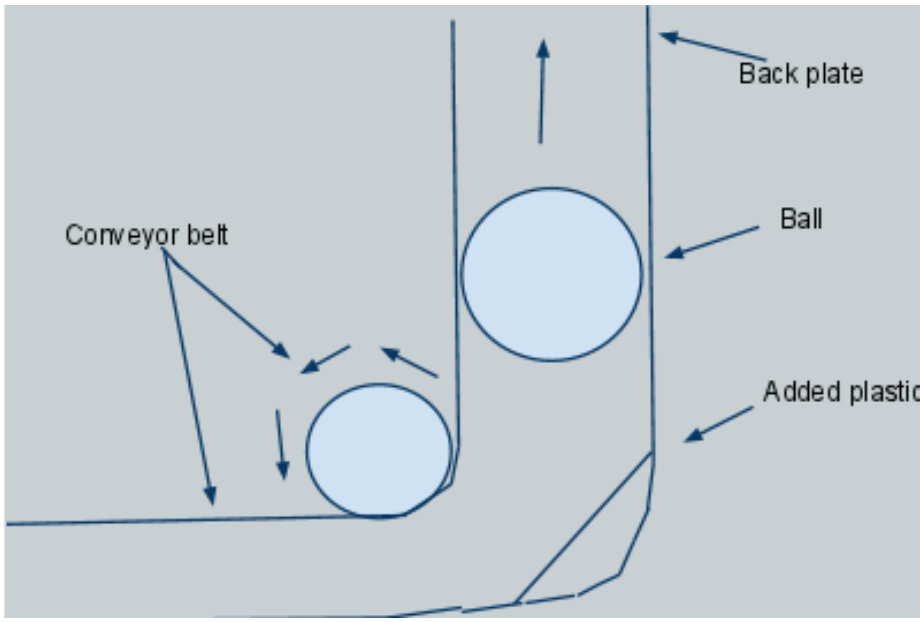


Figure 81**: Illustration of Ramp after Revision**

1/8/10

Meeting 29 continued

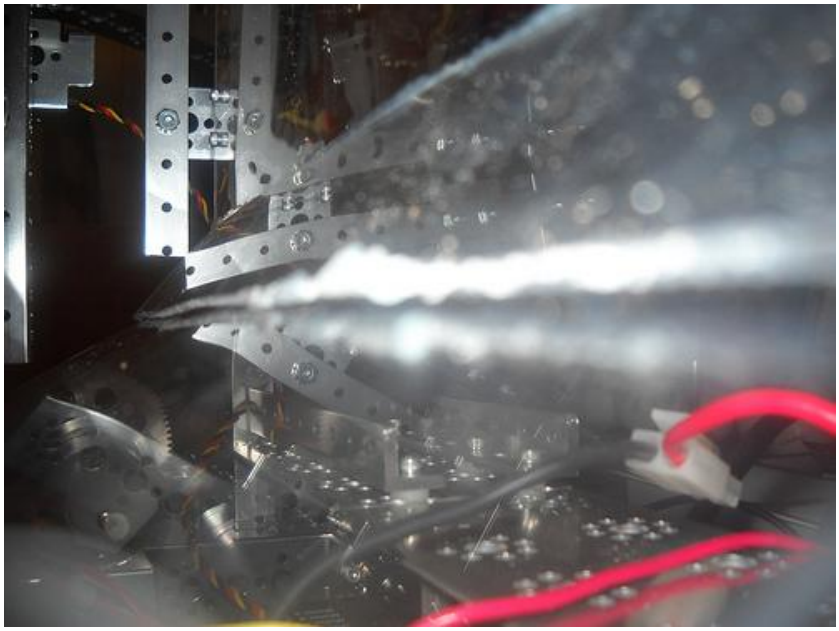


Figure 82**: Image of Added Plastic to Ramp**

Adjust ball ramp and mount

We cut about 1cm off the top so we would have room for the ramp to be bent down a bit more. In order to make the balls roll directly into the ball shooter and not stop in the lip, we decreased the angle in which the plastic was bent, and warped it in to create a channel for the balls to roll down.

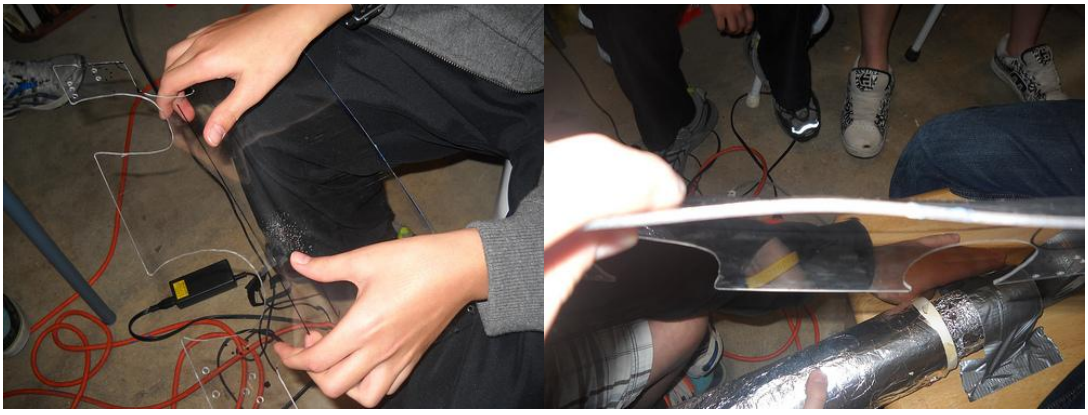


Figure 83**: Top Ball Shooter Ramp and Mounting**

1/8/10

Meeting 29 continued

The robot is really coming together. The **three main parts** are installed, and two have been tested. The ball collector works properly. The flexible arms grip to the balls and bring them in quickly. The conveyor belt needs to be tested, but hopefully it brings the balls from the collector up to the top ramp and down into the ball shooter. The ball shooter has been tested and only needs minor tweaks.

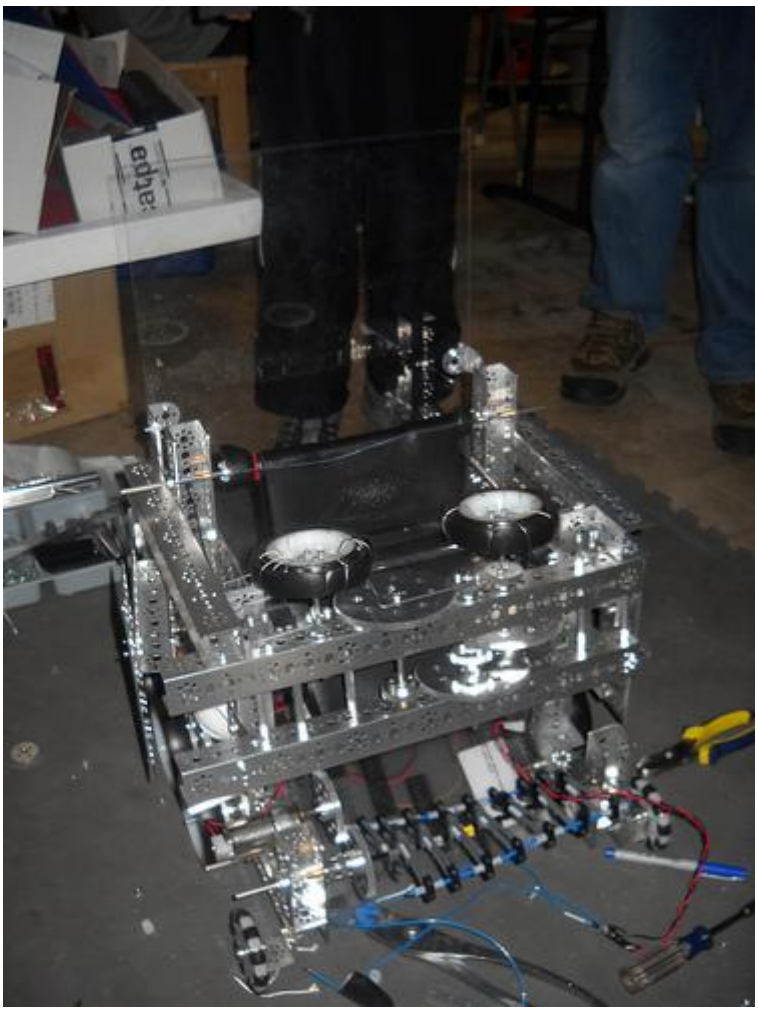


Figure 84**: Robot Coming Together: 3 Main Parts Installed**

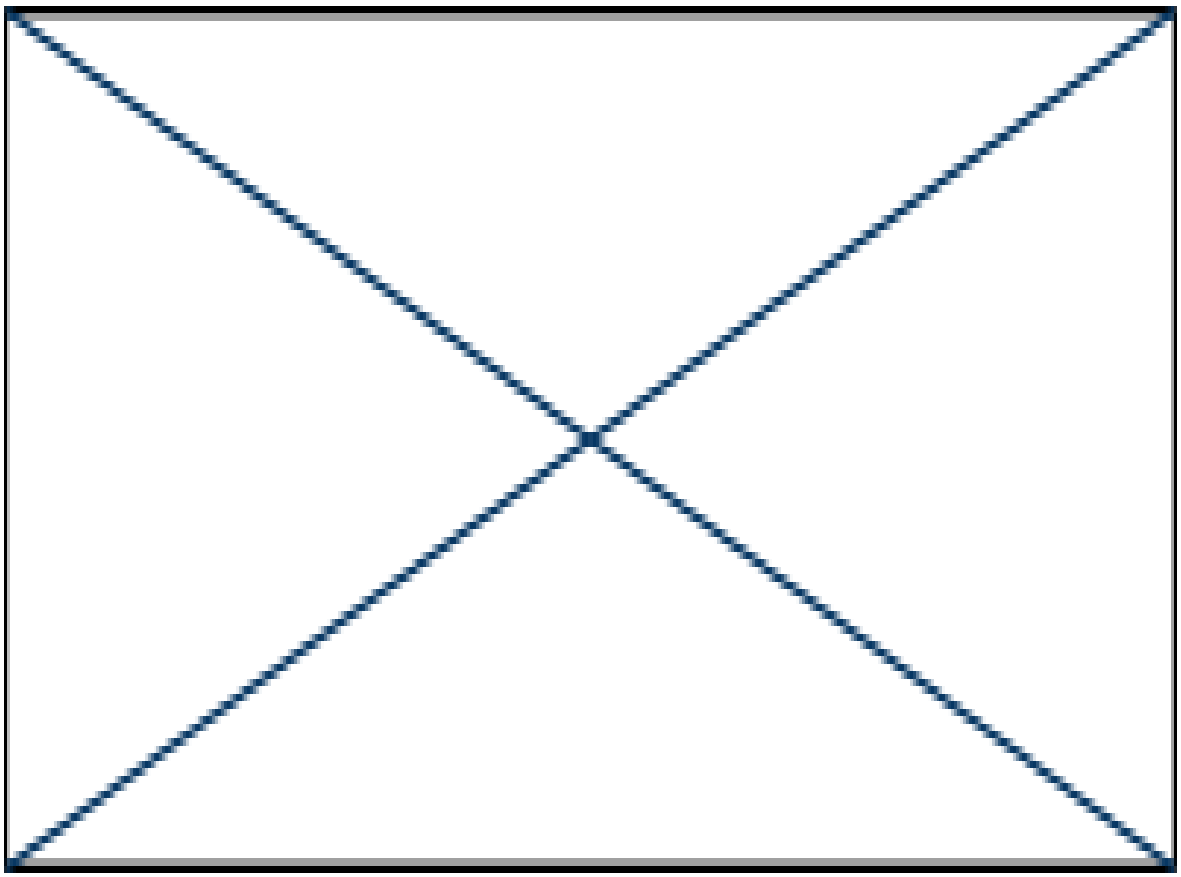
1/8/10

Meeting 29 continued

What needs to be done still are:

- Robot programming
- Ball shooter screws need to be secured with Loctite
- Gear protectors need to be made
- Conveyor belt needs testing
- Several aluminum bars and axles need trimming

With only about four weeks from the competition, we have a lot to do.



Recorded by: A.F	**Date:** 1/8/10	**Reviewed by:** N.O.	**Date:** 1/16/10

1/10/10

Meeting #30

Task	Reflection
Alter conveyor belt to decrease slip.	First we added zip ties to the outside and to hold it in place, but it still slid to the right. We came-up with the idea to notch the PVC shaft on the bottom where it was bunching. The zip ties and part of the belt would go in the notch and hopefully reduce sliding. We only began to remove the shaft to notch the PVC.
Test the Bluetooth connection with the Servo arms.	Bluetooth successfully connected; however the Servo arms' program needs minor revisions as they only opened about 50% of the way.
Test the ball collector and the conveyor belt	We ran into a minor problem when the ball collector arms got caught by the motor of the ball shooter, but we solved it by raising the motor and tying the wire of the motor up with a zip tie. However, the major problem occurred when we realized the conveyor belt shifted to the side, threatening to be torn by the running gear. We are still working on solving this problem.

Conveyor belt

We tested the ball collector which is geared on the same motor as the conveyor belt. The ball collected brought the balls in well to the conveyor belt. The two issues are with the conveyor belt. 1) the belt often doesn't get enough traction to rotate with the shafts, and 2), the belt bunched up to the right side. We run the risk of it ripping when it gets bunched up.

1/10/10

Meeting 30 continued

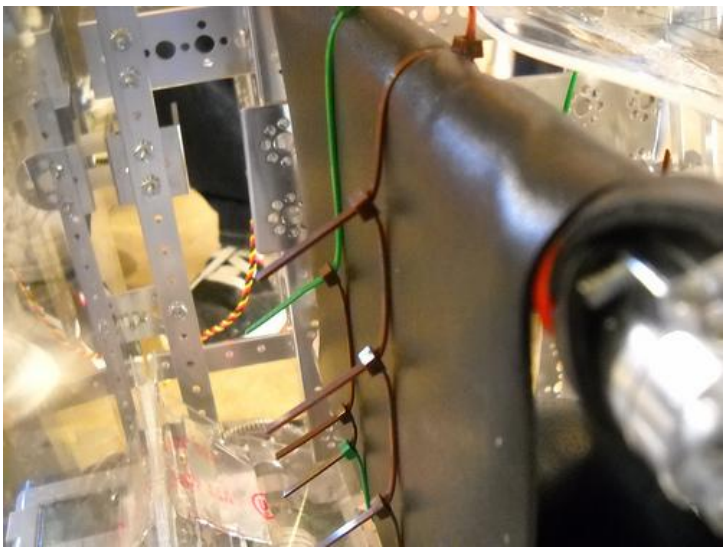


Figure 85**: First test with zip ties**

To attempt to solve this issue we connected many zip ties together to form one long one. We then tightened this around the conveyor belt to attempt to make it tighter solving both these issues. The first test didn't work, so we decided we would try to notch the rod (PVC) on the bottom where the belt was bunching up.

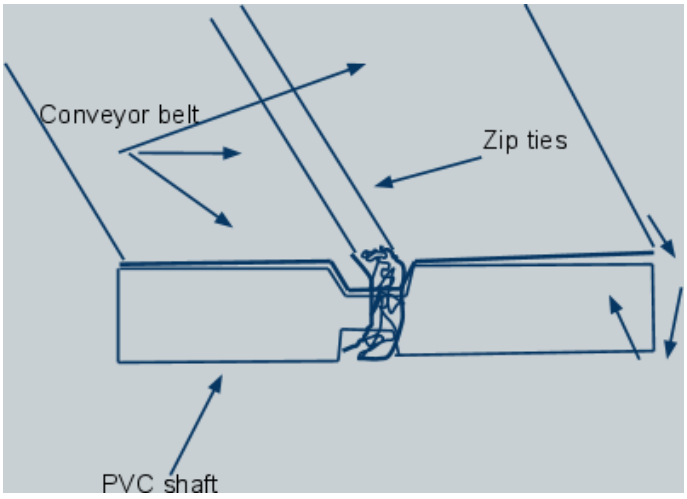
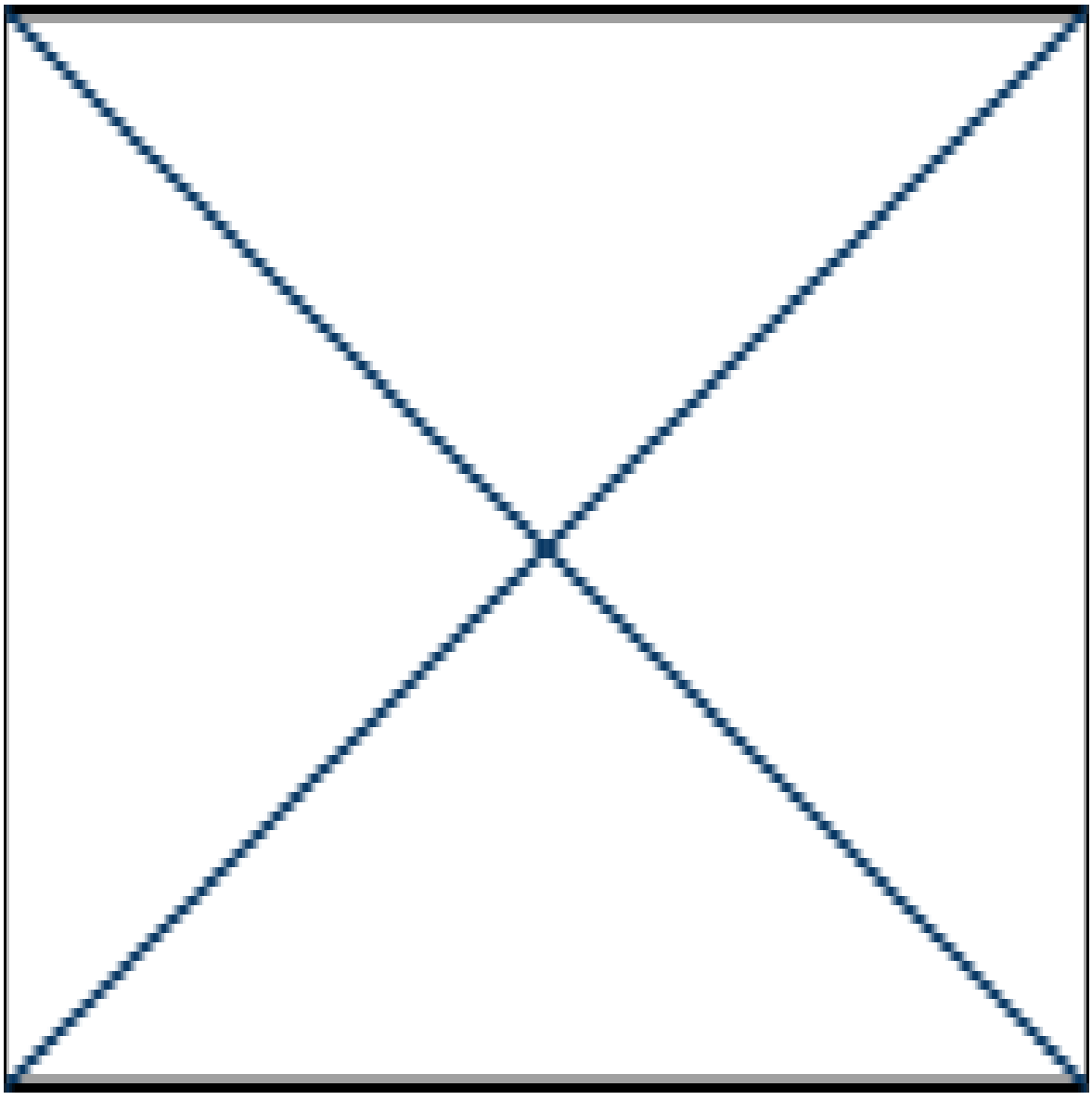


Figure 86**: First test Diagram of what Notch may look like**

1/10/10

Meeting 30 continued

Adding a notch for the conveyor belt and zip ties to fall into would hopefully lock the belt in place making it stay in line.



Recorded by: A.F.	**Date:** 1.12.09	**Reviewed by:** N.O.	**Date:** 1/16/10

1/11/10

Meeting #31

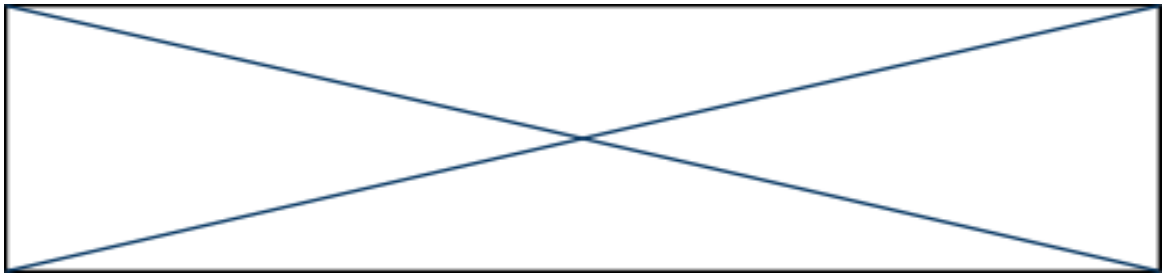
Task	Reflection
Test ball shooter	After last meeting, Sean looked at Peter's program and revised it to make it work. We wanted to test it to see how far different speeds it could shoot at.
Secure ball shooter with Loctite	Most of the shooter was secured, however there are still several pieces of hardware that need to be done.
Continue to work on notching lower shaft to reduce conveyor belt slipping.	The shaft was notches and only needs installing now.

Test Ball Shooter

We tested at 25% speed, and the motor couldn't turn the gears. So we tried 50 and it didn't shoot very far at all. For now we are using 100% power. Each of our tests created new problems to address. Now we know that we need to direct the balls, and have a better way to direct the balls that we shoot.

Loctite

The important parts on the ball shooter were secured with Red Loctite so that when the shooter runs screws don’t’ wiggle out as they have been doing.

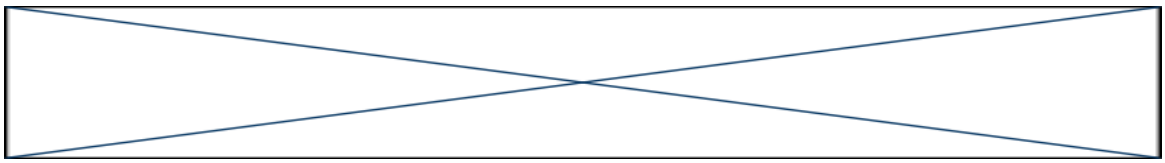


Recorded by: A.F./P.S	Date: 1/11/10	Reviewed by: N.O.	Date: 1/16/10

1/15/10

Meeting #32

Task	Reflection
Finish securing all hardware on ball shooter.	All hardware on the ball shooter was secured with Red Loctite and placed to dry.
Work on program for upcoming scrimmage practice tomorrow.	We've decided not to go the scrimmage due to a large amount of work needing to be done on the robot.
Redesign conveyor belt.	The notch didn't help and the belt still tracked right. This time we've decided to redesign the belt with strips of non-slip pad and secure them with zip ties.
Practice driving the robot and decide on a good team member to drive for the competition.	Had to take the conveyor belt off and didn't have time to test the robot or vote on a driver.
Work on perfecting the robot (e.g. cutting off extra material and aligning gears).	Several long axles were cut down as well as unneeded plastic and aluminum was removed from the robot.
Work on program and table for showing an NXT robot to kids as local elementary schools for community sharing.	There were several problems getting the light sensor to pick up the colors, but with some adjustments it works like a charm now. We plan to show the robot to kids as school on January 29th.
Check plastic coated wire used on robot's ball shooter to make sure they don't exceed the allowed diameter limit.	The plastic coated wire rope was just under the allowed 0.3125'' limit at 0.211'' in diameter.



1/15/10

Meeting 32 continued

Conveyor belt

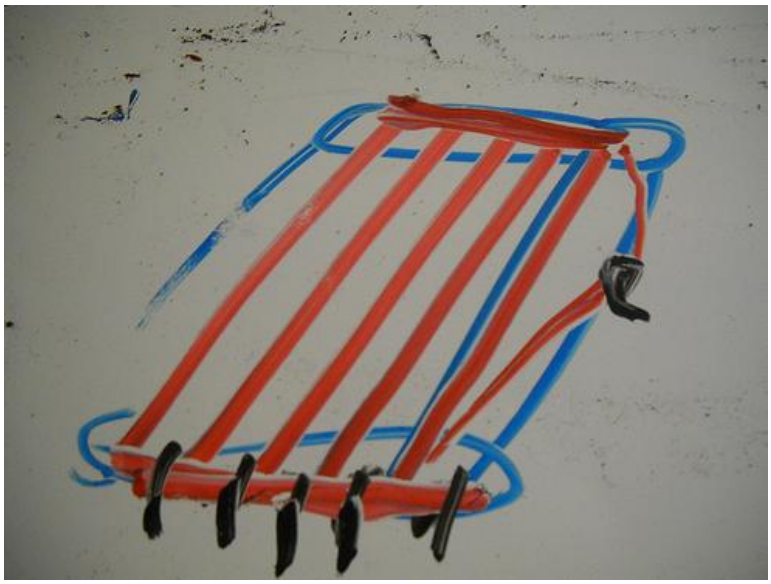


Figure 87**: Conveyor Belt New Concept (White Board Drawing)**

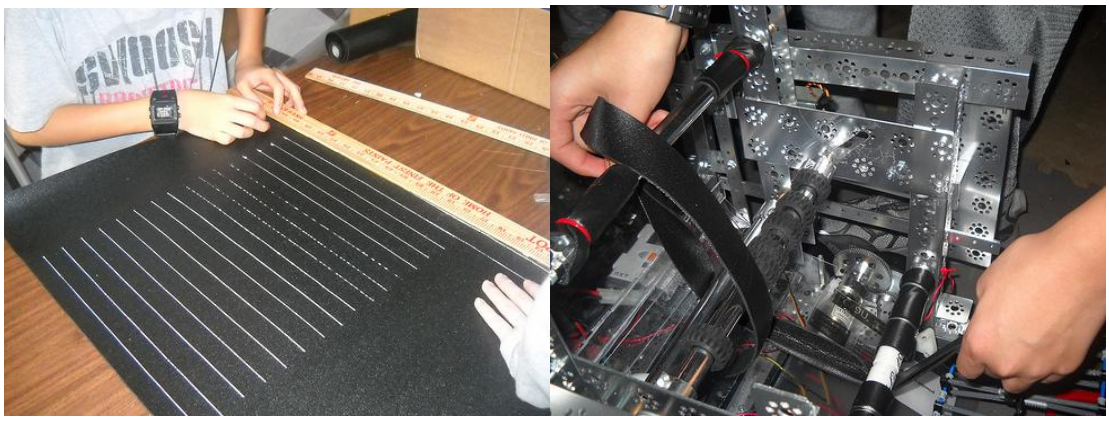


Figure 88**: Cutting Conveyor Belt Strips and Implementation**

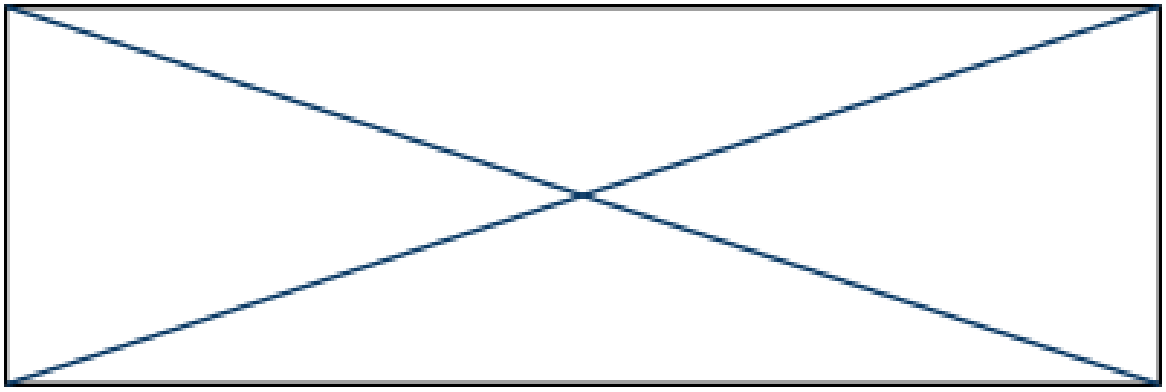
1/15/10

Meeting 32 continued

We felt earlier that the plastic coated rope we had purchased met FTC specifications (0.03 inches), but did not have access to a micrometer to verify this till now. We measured several times in different places. The measurement was always 0.025 inches.

Figure 89**: Micrometer Measurement of Plastic Coated Rope**

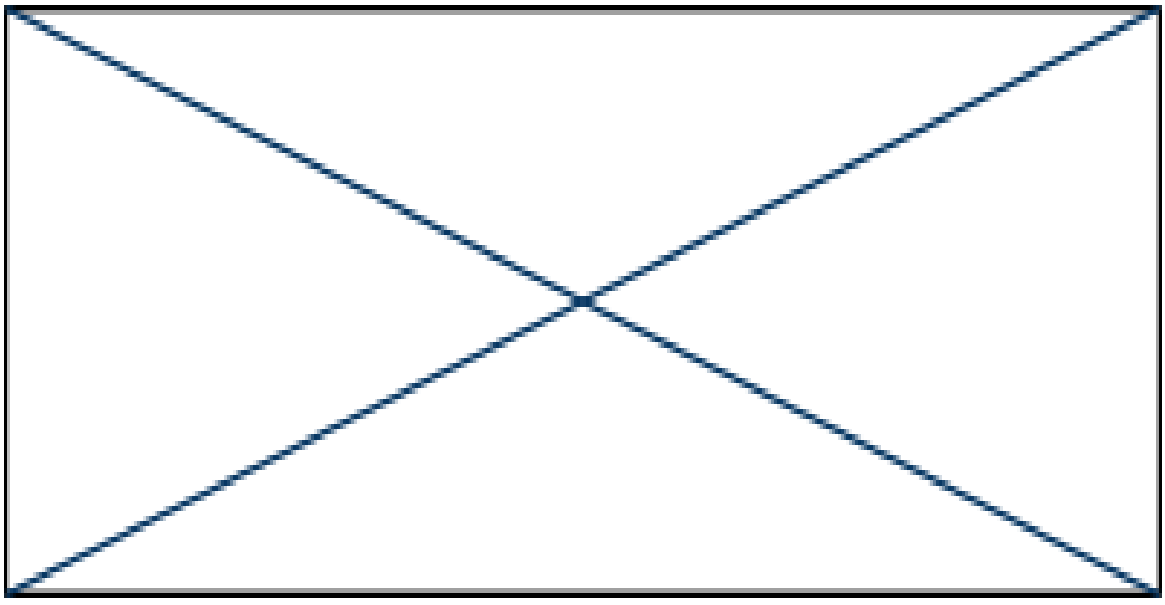
Another component toward our planned Community Sharing project was completed. This was a NXT based robot, that should shoot a dart upon a clap (or loud sound), as we felt that would thrill the kids, and a light sensor to enable it to follow a line and solve a simple maze.



1/15/10

Meeting 32 continued

Figure 90**: Community Sharing Robot**



Recorded by: A.F.	**Date:** 1.15.09	**Reviewed by:** N.O.	**Date:** 1/16/10

1/16/10

Meeting #33

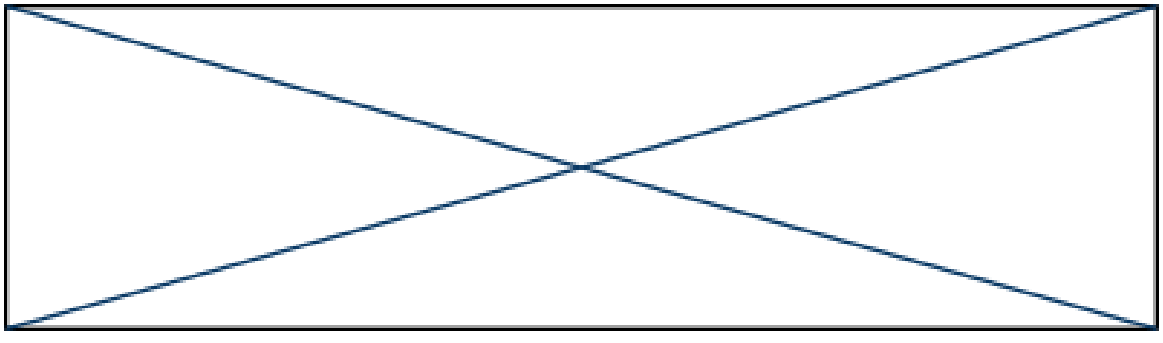
Task	Reflection
Work on ball conveyor belt.	Since zip ties can easily be replaced and shouldn't break, we've decided to make the conveyor belt of of zip ties.
Work on NXT robot for community sharing.	The maze program had been completed and tested. We've talked to two principals from local elementary schools. We have two day set-up to show kids about LEGO robotics and about FIRST for their age.

Conveyor belt

The new conveyor belt was made out of zip ties for easy replacing.

Robot for community sharing

Both the maze and line following programs have been completed. These will be shared with elementary school students soon. We have already scheduled times with the schools principals.



Recorded by: N.O. /A.F.	Date: 1.16.09	Reviewed by:	Date: 1.16.09

1/17/10

Meeting #34

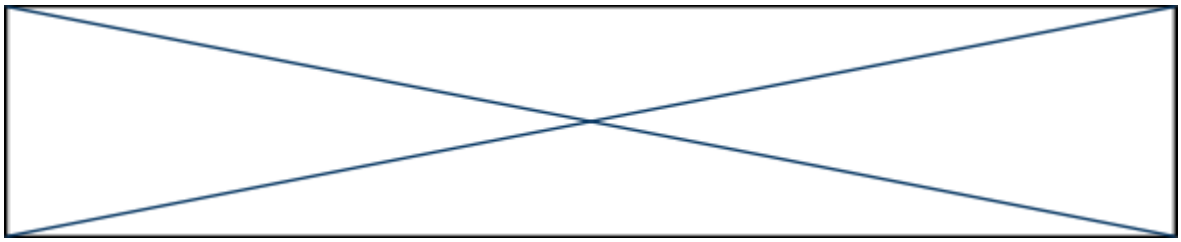
Task	Reflection
Work on ball conveyor belt.	Since zip ties can easily be replaced and shouldn't break, we've decided to make the conveyor belt of zip ties.
Work on NXT robot for community sharing.	The maze program had been completed and tested. We've talked to two principals from local elementary schools. We have two day set-up to show kids about LEGO robotics and about FIRST for their age.

Conveyor belt

The new conveyor belt was made out of zip ties for easy replacing.

Robot for community sharing

Both the maze and line following programs have been completed. These will be shared with elementary school students soon. We have already scheduled times with the schools principals.



Recorded by: N.O. /A.F.	**Date:** 1.16.09	**Reviewed by:** N.O.	**Date:** 1/18/10

1/18/10

Meeting #35

Task	Reflection
Work on building the center goals.	The plastic and PVC was mounted we began work on cutting the net for a basket but didn't it completed yet. Also the holes were drilled into the Plexiglas to attach the bottom of the goal.
Remove current dive axles for conveyor belt and add sprocket and chain to drive all three shafts.	We attached three sprocket gears and got the chain cut and mounted.
Add side rails to ball shooter and diagnose a gear rattle problem.	We first taped the tubes in place then drilled holes to mount them. The balls roll down them without shooting of to the side.
Complete table and robot to show to elementary school kids.	The last bits of tape were added to the table and the robot and program were finished up. Ben and Nathan also began work on a template for us to follow when showing the kids robotics. The made some small parts and got a program ready to on a projector.
Take team photo for website.	We got one photo taken.

Center goals

The plastic was attached to the PVC tubes and mounted on the center base. We started to cut the net for the higher goals but didn't get that finished and mounted.

1/18/10

Meeting 35 continued

Figure 91**: Center High Goal without Back Net**

Figure 92**: Goal Net Being Cut**

1/18/10

Meeting 35 continued

Add sprocket and chain to conveyor belt shafts

The sprocket gears were attached to all three shafts so they would all rotate hopefully encouraging the conveyor belt to rotate too. The chain was cut and installed on the gears, but we didn't get to testing it today.

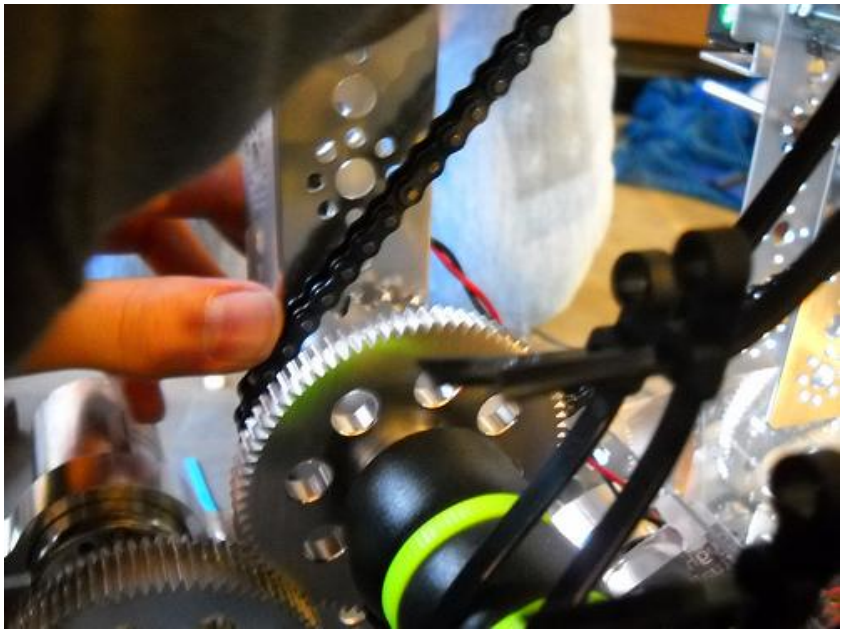
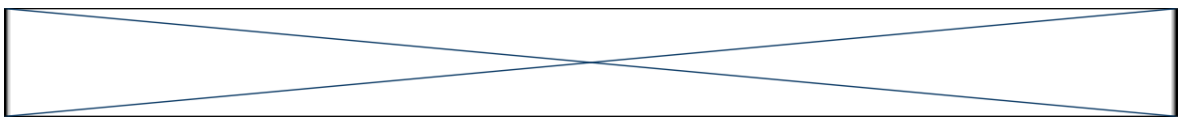


Figure 93**: Chain being mounted on sprocket**

Ball shooter guidance rails

Two holes were drilled in the bottoms of two metal Tetrix tubes. The ends were clamped down to fit under the ball shooter tires to they wouldn't rub. Holes were also put in the plastic ramp and the tubes were mounted onto the plastic.

We've tested this and the balls do roll down the guidance rails and don't fall out the sides anymore. We will still need a cover on the top though.



1/18/10

Meeting 35 continued

Figure 94**: Ball Shooter Guide Tubes in Vice**

Figure 95**: Completed pressed tube end to fit under ball shooter tires**

1/18/10

Meeting 35 continued

Figure 96**: Ball Shooter Guiderails under Test**

Team photo

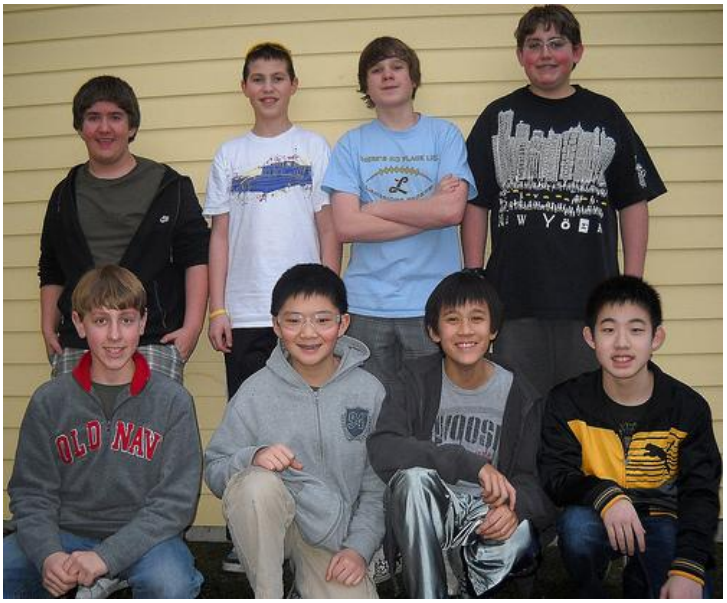
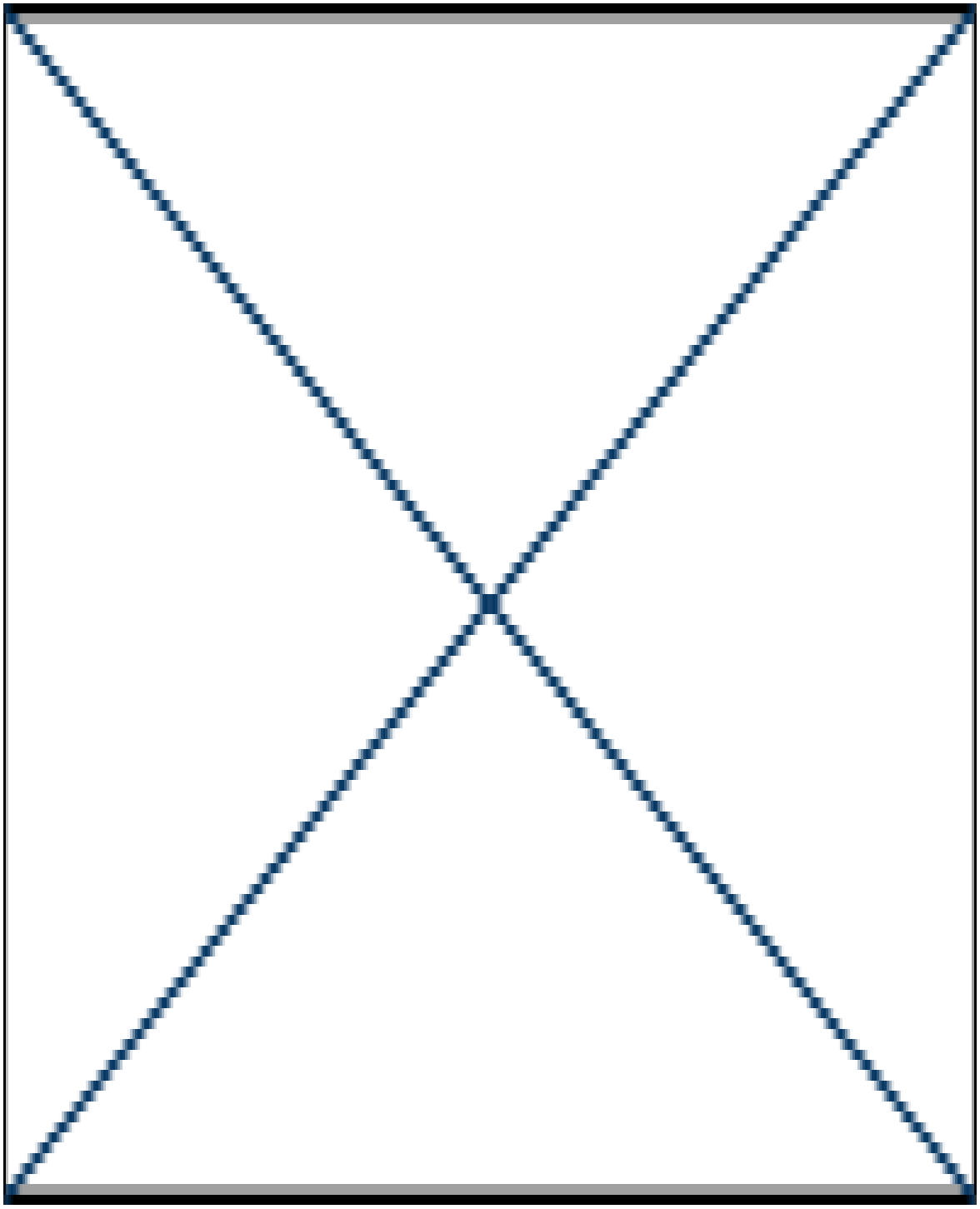


Figure 97**: Team photo**



Recorded by: A.F.	**Date:** 1.18.10	**Reviewed by:** N.0	**Date:** 1.18.10

1/22/10

Meeting #36

Task	Reflection
Review video recorded during community sharing and post on YouTube for judges to see.	We got our video from a combination of three camera. We've also decided not to post it on YouTube for a week or two so other teams don't get any ideas.
Finish cutting screen for high goals.	Screen was cut though not yet mounted.
Add sprocket tensioner to ball collectors chain to reduce slipping	The extra sprocket was added to the chain and now the loose chain has been pushed down.

Community sharing

Today we got a chance to share to elementary school kids about LEGO robotics and FLL. The kids LOVED the robots and enjoyed setting off a sound triggered dart. We hat several hours of video from a combination of three cameras and plan to make a video soon.

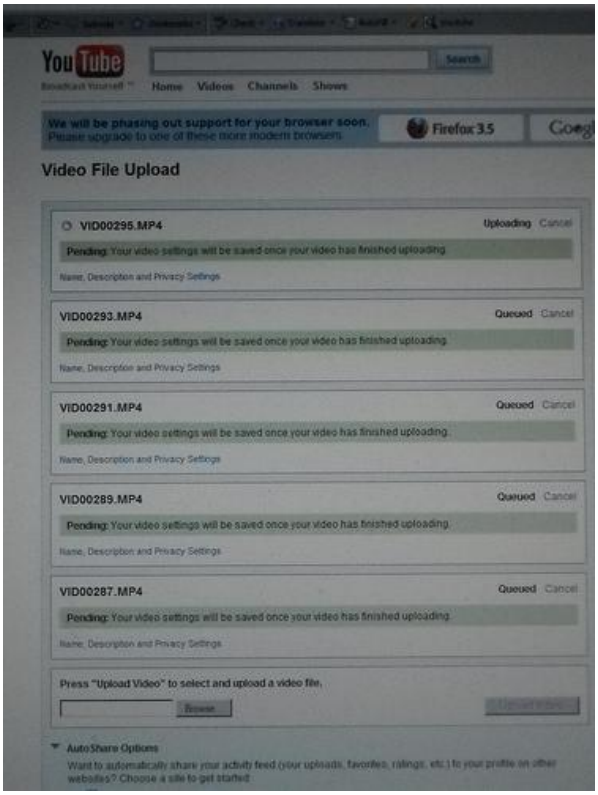


Figure 98**: Uploading videos**

1/22/10

Meeting 36 continued

Field Goals

Our coach helped a little here, but we did most of the work building our FTC field surface. We assembled about one third of the field. Here we are working on the field center target. We've added the plastic to the PVC. Now all that is left if the foam and netting.

Figure 99**: Center Field Goal Net being cut**

Chain sprocket

The extra loose chain was allowing the gears to slip so we added a tension sprocket and now it is tight (though not too tight).

1/22/10

Meeting 36 continued

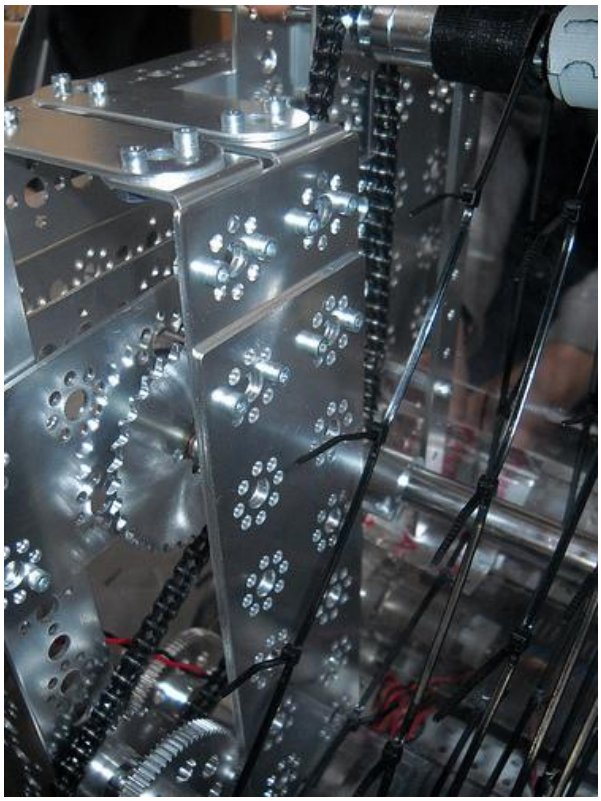
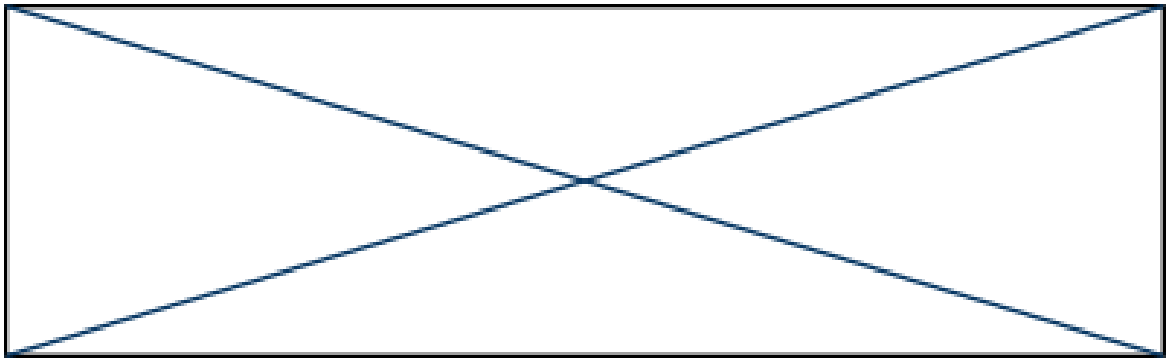


Figure 100**: Tension Sprocket Addition**



Recorded by: A.F.	**Date:** 1/22/10	**Reviewed by:** N.O.	**Date:** 1/29/10

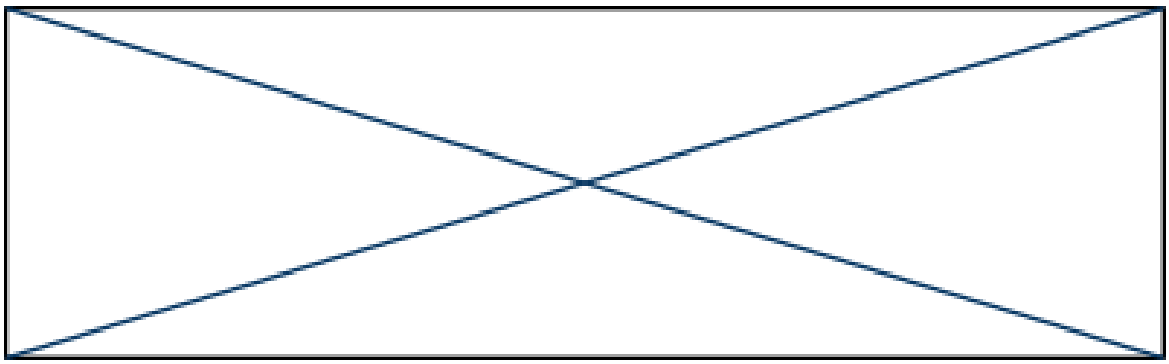
1/24/10

Meeting #37

Task	Reflection
Add walls to the sides of the ball conveyor belt so balls don't get stuck or in the way and test belt.	We made temporary cardboard balls so the balls wouldn't get stuck in the chain and mounted them on the right and left sides of the belt. We then replaced the cardboard walls with Tetrix metal plates.
Replace larger conveyor belt zip ties with small ones so the belt will flex more to go around the shafts.	We mounted small zip ties and they worked very well. The larger ones weren't as flexible and sometimes didn't rotate. The smaller ones also seem to hold the balls better.
Adjust NXT robot program to show to another elementary school on Friday.	The dart shooting program needed more power to shoot more reliably. With the new updates, the motor rotates 25° now rather than our previous 15° program.
Review community sharing footage, upload to Flickr, and begin combining clips for video.	All of the photos and videos were uploaded to Flickr, however Aaron is going to edit the footage at home so he can use a program that he has on his computer. We've also updated out website (untitled8.org) with more community sharing photos and information.

Conveyor belt

Side walls - the made mock-ups out of cardboard to see how these work and they work great. They keep the balls from hitting any moving parts that they may damage.



1/24/10

Meeting 37 continued

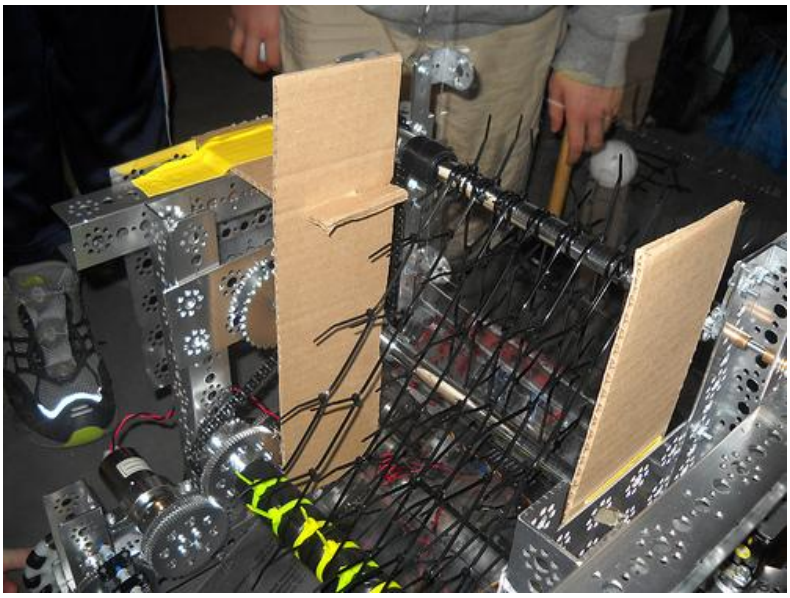


Figure 101**: Mock-up side guards**

Zip Ties - we replaced the large zip ties with small ones that are thinner and more flexible to grip the balls and shafts better. This is the first well working belt we have come-up with.

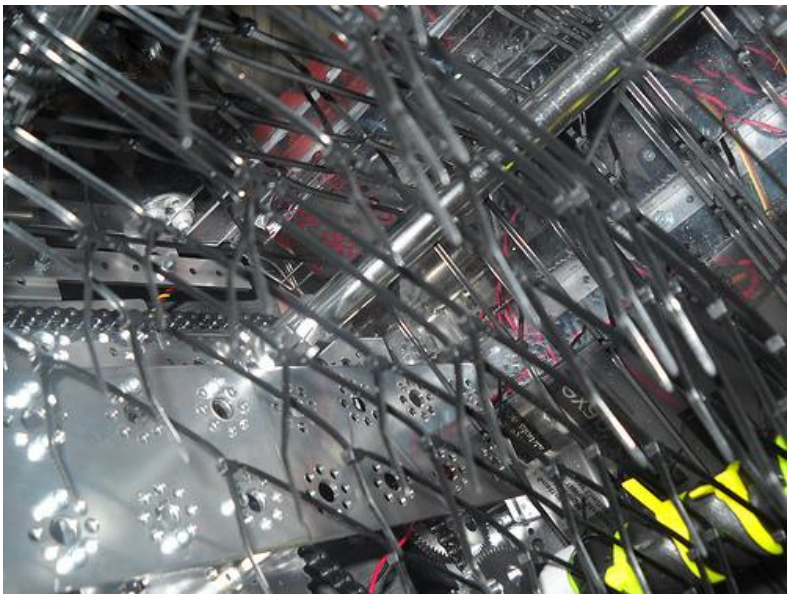


Figure 102**: New zip tie conveyor belt**

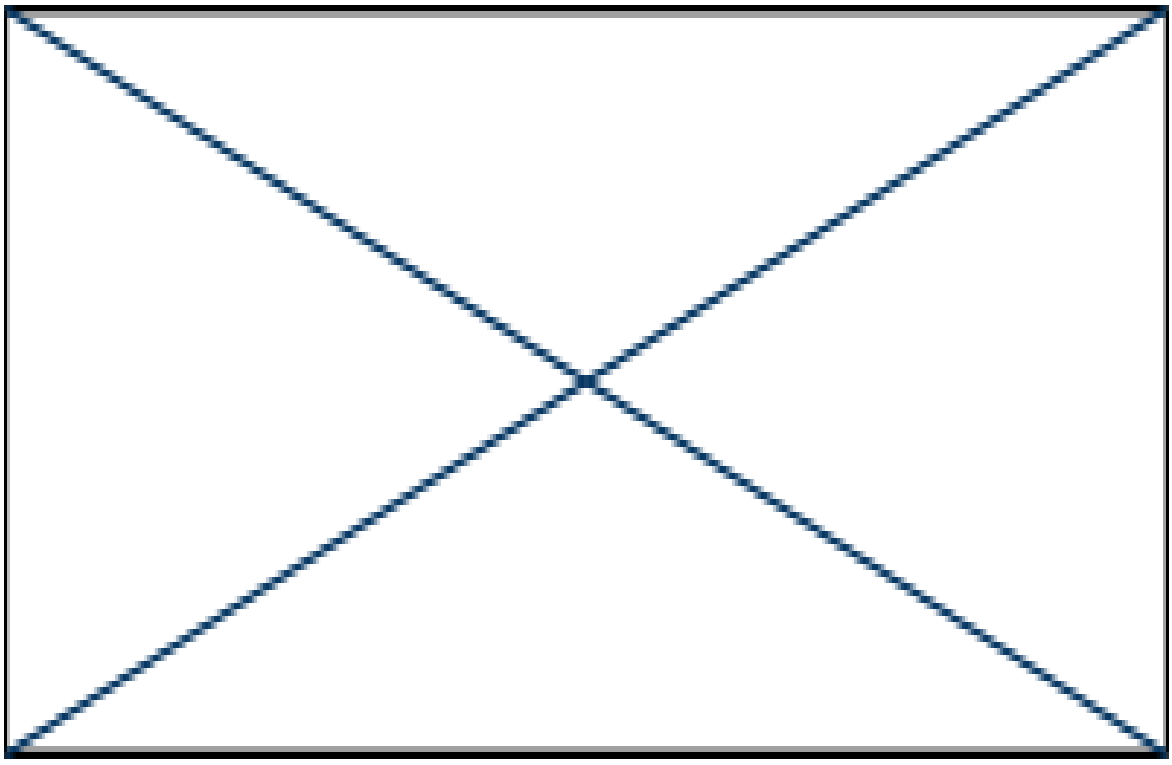
1/24/10

Meeting 37 continued

Community sharing footage

Last Friday (22/10) we shared several LEGO robots and out Tetrix robot with 3rd, 4th, 5th, and 6th graders at Rivergrove elementary school. The feedback received was tremendous. The kids loved the moving robots and many said they wanted to sign up with an FLL robotics team.

We also got some great videos and pictures to share with judges. Aaron will take the videos home and make a video to them be posted on YouTube.



Recorded by: A.F.	**Date:** 1.24.10	**Reviewed by:** N.O.	**Date:** 1/29/10

1/29/10

Meeting #38

Task	Reflection
Make and design posters for presentation	We are designing our posters using PowerPoint. We are taking our PowerPoint slides from our presentation last year and we are editing them to fit this year's project.
Fix ball shooter	Several gears and set-screws were loose from adjustments. These were quickly put back in place.
Make new servo arms	The new arms are made with thinner and long arms to trip the ball shoot lever.
Take new team picture	We took a lot of pictures. It took us while but we finally got a good one.

New servo arms

The old ones were wide and short and not able to reach the ball shoot lever.

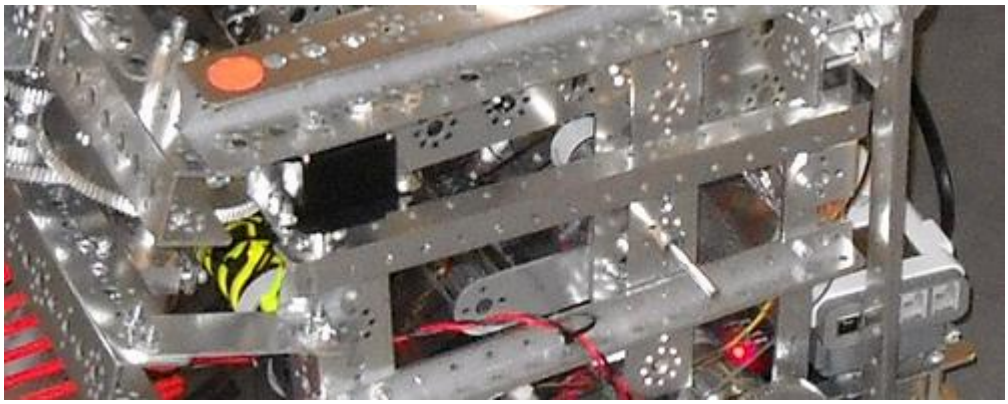


Figure 103**: New Servo Arms**

1/29/10

Meeting 38 continued

Team photo

Figure 104**: New Team Photo (Tee-shirts Arrived)**

Recorded by: NO	**Date:** 1/29/10	**Reviewed by:** A.F.	**Date:** 1/29/10

1/30/10

Meeting #39

Task	Reflection
Go to scrimmage at Hillsboro High School.	This was a great opportunity for our team. We were able to talk with several experts and acquire information required to advance us. Another great thing was that we were able to test our robot on a full field and scrimmage. This was hard and we were able to see which team members were really interested in driving.

Scrimmage

Going to this scrimmage was a great idea. We had the opportunity to talk with Mr. Jordan about out lab notebook, and with Mr. McBride about our program.

We had a great long work-time and made some minor adjustments on the robot:

1. Cut off extra plastic on-top of robot

A large unnecessary piece of plastic was hanging above the top of the robot. We had to do something as it was making to robots height over the limit of 18''. We simply cut this off and everything still works fine.

2. Replace current ball collect that falls apart with shorter red flexible LEGO pieces

Our previous ball collector design was purely LEGO pieces and they didn't stay together when rotating and rubbing against balls. We found some red flexible LEGO's that fit tightly in the holes of the Tetrix flat shaft.

1/30/10

Meeting 39 continued

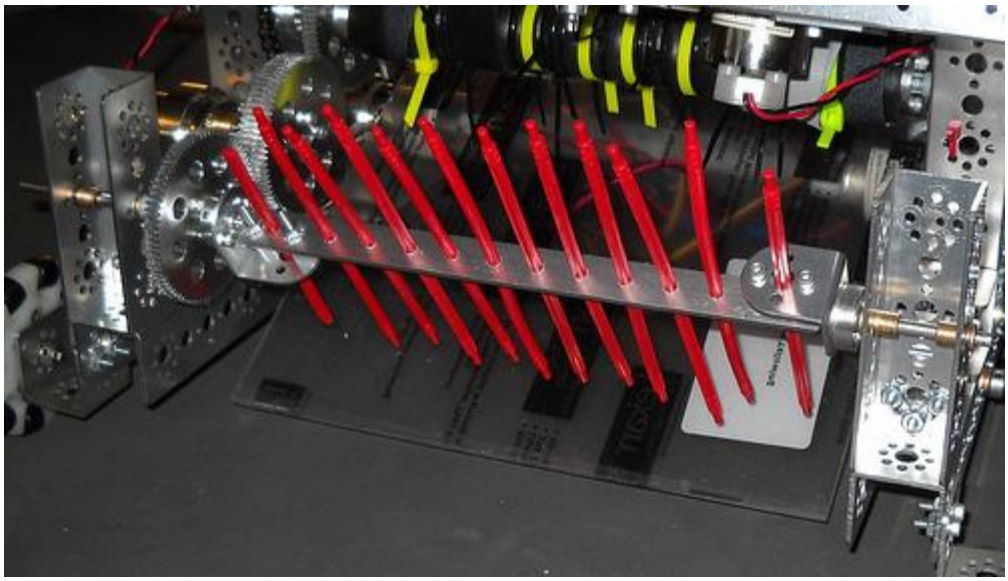


Figure 105**: Updated Ball Collector with New Lego Pieces**

3. Start on our project posters (the team, the robot/programs,

Andrew launched out "The Team" poster.

Key features:

- Team photo
- What we're learning
- Team Values
- Pictures from Scrimmage

Recorded by:	**Date:**	**Reviewed by:**	**Date:**
A.F.	1/30/10	N.O.	1/30/10

1/31/10

Meeting #40

Task	Reflection
Work on, print, and mount slides for our four display boards (community sharing, programs, robot, team).	Most of The "The Team" board was printed and temporally set on the board. Two poster boards with our team poster attached were also put together. These will go in our pit area at the completion.
Test and practice robot	Since the main parts of the robot have been completed, we were able to drive the robot around. We took turns on the field driving in a straight line then turning around 180° , and finally returning to the start box. When we mastered that we moved onto a more challenging task, parking next to the ball shoot lever and hitting the lever with the servo arms. We turned the ball collector on and aligned the robot with the outer scoring boxes.
Begin Bill of Materials (BOM).	Andrew started on this. It'll be a long project but has a good foundation.

Display Boards

We are dividing and conquering here. Andrew is handling much of Community Sharing, Peter on the technical board with Wren assisting, and Ben and Nate tackling the team poster board.

1/31/10

Meeting 40 continued

We still have problems but the robot appears (with every little mechanical tweak) it is becoming a little more robust.

Robot field testing

Figure 106**: Robot Field Testing**

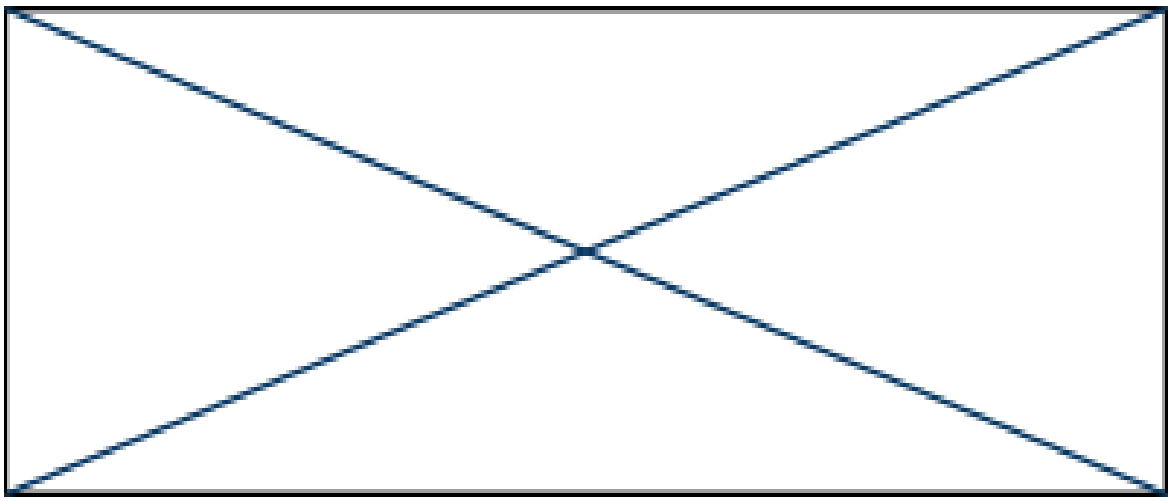
Recorded by:	Date:	Reviewed by:	Date:
A.F.	1/31/10	N.O.	1/31/10

2/1/10

Meeting #41

Task	Reflection
Move the front wheels back so the robot will fit the size restrictions.	
Tighten all of the screws on the robot with our new Allen wrenches.	
Improve the shooter and program it to shoot balls into the one point zone during the autonomous part of the match.	

Not much to report today…. Mostly because we all seem to have dropped the ball getting information in our lab book. So crazy busy trying to tie up loose ends.



Recorded by:	Date:	Reviewed by:	Date:
A.F.	2/1/10	N.O.	2/1/10

2/3/10

Meeting #42

Task	Reflection
Continue to work on and print poster project boards.	The "The Team" board was fully completed and the robot/program board was finished on the computer but is still waiting to be printed and mounted.
Work on engineering notebook.	This needs some work. Today we did some formatting and grammar checking.
Go to last minute scrimmage at Portland Tech Shop.	We took our robot to Portland Tech Shop for a few hours to again try it out on a full field. We found several issues that will need fixing. This was a great opportunity.
Finish Bill of Materials.	We finished recording the main parts of the robot. This can be finished tomorrow easily.

Project board

Work Continues….

Scrimmage

We happened to learn about this and requested to participate… And really glad we did! This was a really good experience as we think we have good ideas on how to address some of the outstanding issues of the robot performance.

2/03/10

Meeting 43 continued

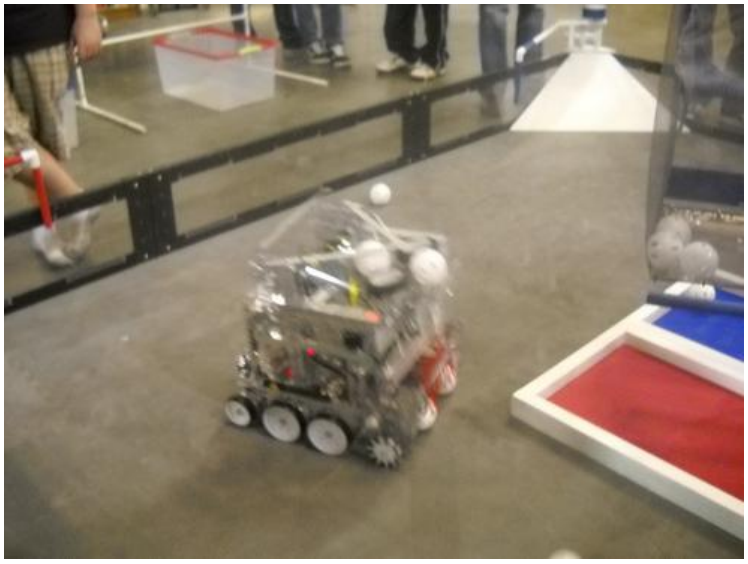


Figure 107**: Robot in Scrimmage at Tech Shop**

BTW… Portland Tech Shop is a really COOL Place!!!!

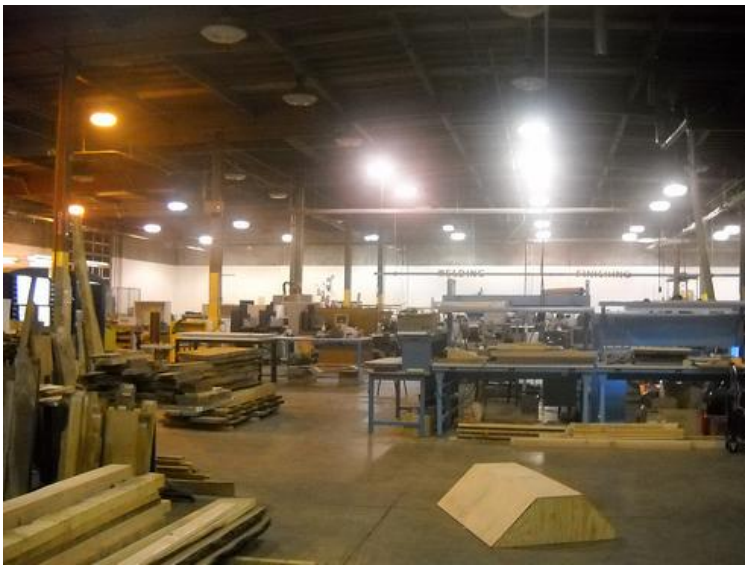


Figure 108**: Portland Tech Shop**

Recorded by:	**Date:**	**Reviewed by:**	**Date:**
A.F.	2/3/10	P.S.	2/3/10

2/4/10

Meeting #43

Task	Reflection
Final Robot Details	We geared up the ball shooter turn buckle device, and fashioned PVC snap-on spacers to keep the zip tides regular spaced.
Work on engineering notebook.	Wrapping it up
Finish Bill of Materials.	Finished

Project board

Done! Need to print them out…

Final Robot Details

We crafted our own spacers out of 1/2 inch and 3/4 inch PVC. We cut them in ¼ slices, and then cut through one side of both (to make a snap-ring) so could snap onto the zip-tie belt drive shaft. We had to ream out the ½ PVC a bit so that it would fit around the Tetrix tubing. The ¾ inch snap-ring was glued (using PVC cement) on top of the ½ inch snap-ring to give more height to prevent the zip-tides from moving over them.

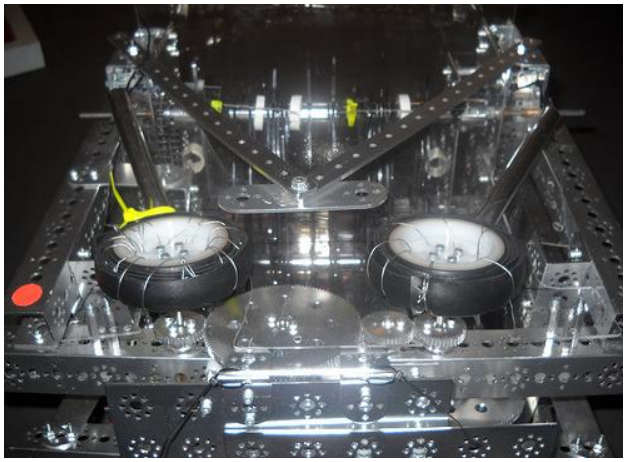


Figure 109**: Zip-tie Drive with PVC Spacers**

2/4/10

Meeting 43 continued

We then tried to increase the speed of the ball collector turn buckle so it would knock the wiffle balls more efficiently up the ball collector ramp. The results were quite dramatic as it worked enormously better!

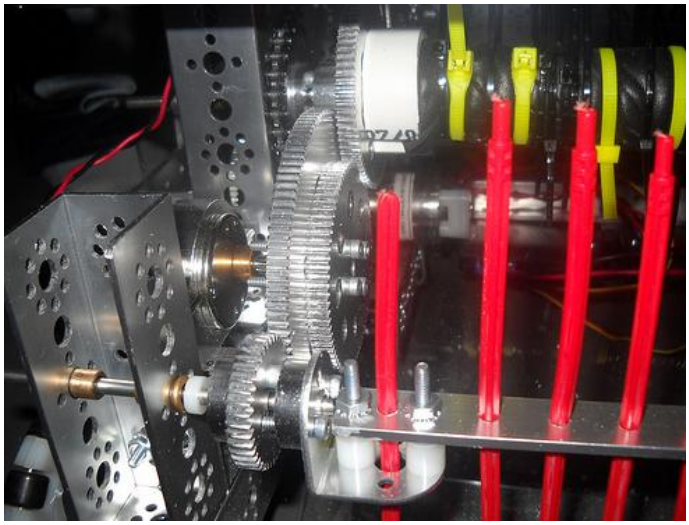


Figure 110**: Ball Collector Gearing Improvement**

Pro/ENGINEER CAD

Sean had been experimenting with the student version made available to FTC by PTC. It is not easy software to use without training, and the documentation is kind of hard to understand. He figured out that when laying down components into an assembly that one needs to lock them down with at least three constraints, else they will move or spin in some undesirable way. Another problem is that when performing middle mouse clicks with certain windows open will cause the software to crash, and one would lose all their work to that point. ProE only let's one save the "assembly" after the component constraints have been complied or one gets out of the edit mode, but one can do a lot of work in that state when it crashes. So one must be careful.

He had been working on this in his spare time. The figure below shows how far he got. He plans to teach us all how to use it, as this can be very useful tool in the future.

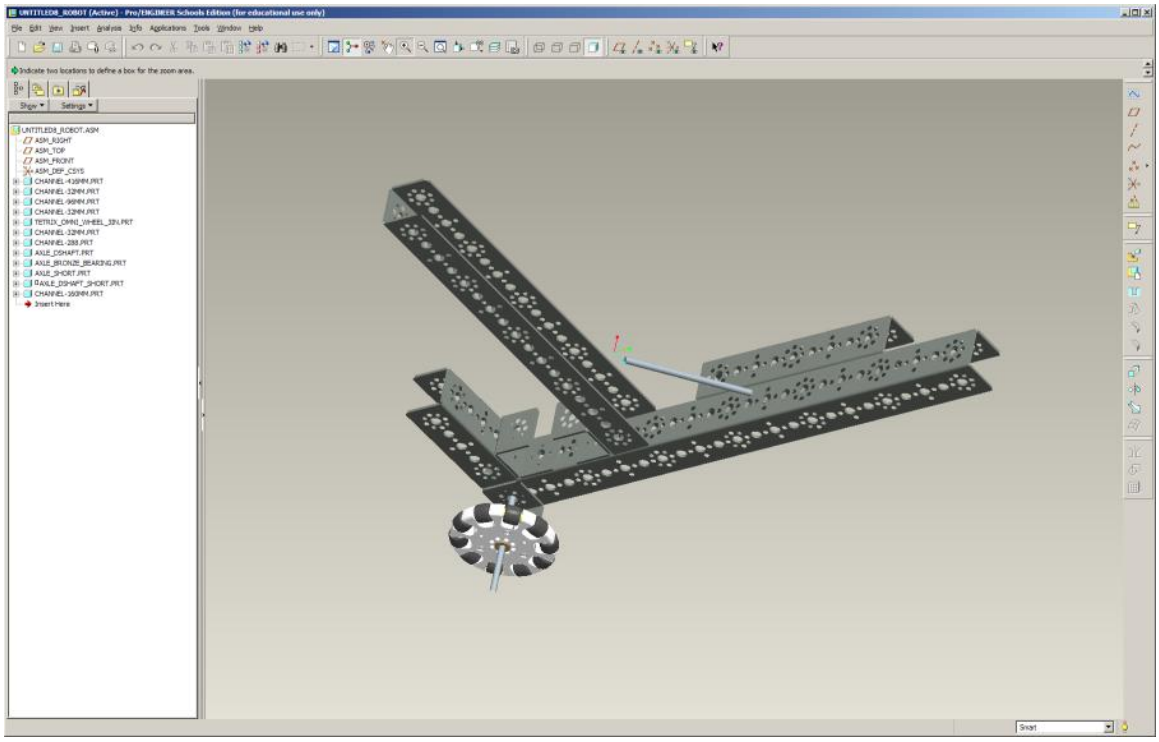
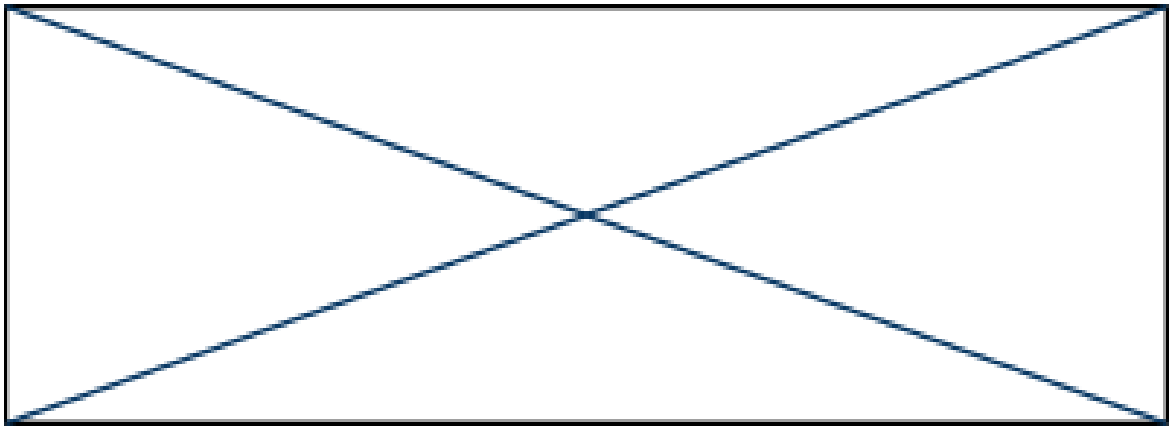


Figure 111**: Pro/ENGINEER CAD Robot Design Capture**

Yay! We had soooo much fun…

GO FTC! See Ya at the Competition! ☺

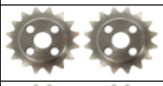
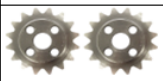
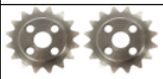


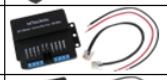
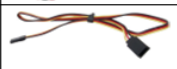
Recorded by:	Date:	Reviewed by:	Date:
A.F.,S.K.	2/5/10	A.F.,N.O.,S.K.,V.C.,P.S.,W.H.,A.L.B.C.	2/5/10

Appendix

Bill of Materials (BOM)

Untitled-8 FTC Robot BOM

Type	Part #	Quantity	Description	Illustration
Structural Element	W739069	4	TETRIX™ Channel (416 mm)	
	W739068	6	TETRIX™ Channel (288 mm)	
	W739066	5	TETRIX™ Channel (96 mm)	
	W739065	13	TETRIX™ Channel (32 mm)	
	W739070	6	TETRIX™ Flat bar	
	W739070	1	TETRIX™ Flat bar Cut to 9.25 inch	
	W739070	1	TETRIX™ Flat bar Cut to 8.875 inch	
	W739070	2	TETRIX™ Flat bar Cut to 5.625 inch	
	W739071	7	TETRIX™ Angles (288 mm)	
	W739071	2	TETRIX™ Angles (288 mm) Cut to 10.0 inch	
Gears	W739028	9	TETRIX™ Gears (40-tooth)	
	W739086	9	TETRIX™ Gears (80-tooth)	
	W739085	3	TETRIX™ Gears (120-tooth)	
	W739165	2	TETRIX™ 16-Tooth Sprocket Pack	
	W739169	1	TETRIX™ 24-Tooth Sprocket Pack	
	W739171	1	TETRIX™ 36-Tooth Sprocket Pack	
Wheels and Axles	W731132	2	TETRIX™ Omni Wheels	
	W739055	4	TETRIX™ 4" Wheel	

	W739025	4	TETRIX™ 3" Wheel	
	W739091	43	TETRIX™ Bronze Bushings	
	W739088	20	TETRIX™ Axles	
	W739092	25	TETRIX™ Axle Set Collars	
Fasteners	W739098	25	TETRIX™ Socket Head Cap Screws (5/16")	
	W739097	160	TETRIX™ Socket Head Cap Screws (1/2")	
	W739094	191	TETRIX™ Kep Nuts	
	W739111	28	TETRIX™ Button Head Cap Screws	
	Part of W739090	20	TETRIX™ Socket Head Cap Screws (1 3/8')	
Brackets	W739089	5	TETRIX™ Motor Mount	
	W739060	2	TETRIX™ Single-Servo Motor Brackets	
	W739061	7	TETRIX™ Flat Brackets	
	W739062	14	TETRIX™ L Brackets	
Motors and Connectors	W739057	1	TETRIX™ 12V Rechargeable NiMh Battery Pack	
	W739083	6	TETRIX™ DC Drive Motor	
	W739080	2	TETRIX™ Servo	
	W991444	3	HiTechnic DC Motor Controller	
	W991445	1	HiTechnic Servo Controller	
	W731903	6	TETRIX™ Motor Power Cable	
	W739081	2	TETRIX™ Servo Extension	
Clamps, Hubs, and Spacers	W739100	17	TETRIX™ Axle Spacers (1/8")	
	W739101	14	TETRIX™ Axle Spacers (3/8")	

	W739090	4	TETRIX™ Gear Hub Spacers	
	W739077	6	TETRIX™ Tube Clamps	
	W739079	7	TETRIX™ Motor Shaft Hubs	
	W739172	14	TETRIX™ Axle Hubs	
Miscellaneous	W739173	1	TETRIX™ Chain with Links Need 28.5 inches	
	N/A	416 square inches	Plexiglass/Lexan	
	W739103	7	TETRIX™ Stand-Off Posts (2")	
	W739102	25	TETRIX™ Stand-Off Posts (1")	
	N/A	76	Wire ties	
	W739193	6	TETRIX™ Tube Plug Pack	
	W739076	3	TETRIX™ Tubes (220 mm)	
	W739075	2	TETRIX™ Tubes (145 mm)	
	W739075	2	TETRIX™ Tubes Cut to 24.5 mm	
	N/A	31.5"	Plastic Covered Wire Rope (0.025 inch diameter)	
	N/A	xxx	Loctite Thread Locker	
	N/A	2	Non-slip pad (for ball shooter wheels) 0.75 x 25.0 inch strip	Home Depot SKU #134555
	N/A	1	Non-slip pad (for main ball collector drive) 3.0 x 8.0 inch strip	Home Depot SKU #134555
	N/A	1	0.5 inch Diam PVC pipe SCH40 7.5 inches	Used as spacers
	N/A	4	0.5 inch Diam PVC pipe SCH40 0.25 inches	Used as spacers
	N/A	6	0.75 inch Diam PVC pipe SCH40 0.25 inches	Used as spacers
	GE9D098B	xxx	Plexiglass Glue	
	N/A	12	LEGO® Red Hose, Soft Axle 16	
	3207607037	210	4 inch Cable Ties (Zip tides) Home Depot	
	3207607013	12	8 inch Cable Ties (Zip tides) Home Depot	