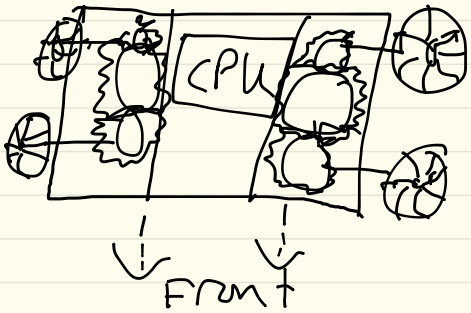
Design Notebook

Square Bot Day 1

01/20/2015

- We pulled out the major parts, but left the screws in our kit
- Simple assembly is just that... simple
- I like making my robot asthetically pleasing, but I have been told that "it's a robot. Function always trumps form."
- we created the outer and inner chasis first.
- then, we assembled the motors & connected them through the inner chasis to the gears
- the gears are connected to the wheels through the outer chasis.
- our group dynamic is great! Nitkin and Sin (?) are both very skilled & think well on their feet. There is no power struggle or disagreement.
- I think the robot will look something like this:

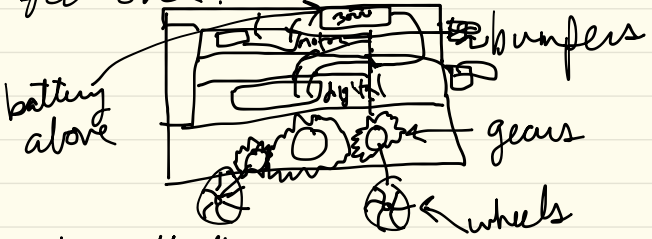


- the collars don't seem to be very effective
- step 5: Chasis subassembly with the screws is so frustrating

Square Bot Day 2

01/22/2015

- Since the chasis was already assembled, we simply had to assemble the canopy and wire the robot.
- The instructions became a bit confusing because we were not using the vex rechargeable battery.
- After assembly, our robot went crazy and started panic driving due to incorrect wiring
  - The instructions mentioned plugging the left & right motors into ports 2 & 3, but they needed to be in ports 1 & 10
- The teleoperation & autonomous mode steps were very easy.
- it's like giving life to metal
- the screws were so hard to install!
- I felt the instructions should have been reordered.
  - we should have plugged in the motors prior to the upper balcony
- A lot of the rules for building these robots seem to be logical & self-learned
  - e.g. using spacers & where to put screws & bringing in rubber bands
- when enabling autonomous mode, we lose all teleoperation
- the breaker serves as the logical switch for the bumpers
  - in the 2nd class demo, we were shown a robot that worked with a remote but could operate autonomously when it fell over.



- Rather easy since all the programs are predefined.

Microcontroller Programming Day 1

01/27/15

- Our goal this week is to construct the programs used to allow autonomous operation of the Squarebot
- No hardware this week, only code
- RobotC uses C programming language
- C is an object-oriented language that works much the same way as Java
  - in C, you use writeDebugStream() to print to the verbose debug log.
    - writeDebugStream() takes any value, but they must be specified with a type first
      - ↳ e.g. ("%d", 5) ("%s", "happy")
- We started by learning about C & connecting our robot w/ the program
- The first assignment is to write a function int hailstone(int n) that returns the next integer in the hailstone sequence
  - ↳ this sequence always returns to one (not proven)

$$f(n)\begin{cases} n_{i+1}=n_i/2 & \text{if } n_i \text{ is even} \\ n_{i+1}=3n_i+1 & \text{if } n_i \text{ is odd} \end{cases}$$

- This function was easily defined. We used if and else if statements.
- I had to rewrite the code a couple of times
  - ↳ 1) to get the sequence and recursion working
    2) to put a line between each element
    3) To properly run hailstone from the main method
    4) optimize the code & move writeDebugStream("%d \n", n); to the top of the code to run before the if statement
- RobotC programs need to wait upon running to account for the time needed by the firmware

Microcontroller Programming Day 1 (cont...) 01/27/15

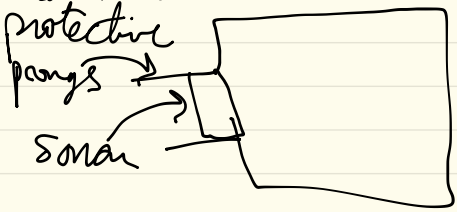
- The second assignment is to write a program that adjusts the speed of the motor to the amount of light received by the light sensor
- the actual definition of the program was made for easier by the example code given to us. The light sensor is imported via a #pragma config(Sensor, in1, lit, sensorReflective) command
- the rest works just like any OO programming language.
- the real trick is getting the motor to scale with the light.
  - The range of the sensor is 1023
  - The range of the motor is 127
  - Thus the scale is the range of motor / the range of sensor
    - in this case we divide the sensor_value by 8.
- However, we still had the motor running indirectly proportional to the light
  - ↳ this is because the darkest value is ~1023 while the slowest value is 0 for the motor
- We thus had to reverse the polarity of the light sensor. Because I noticed the light sensor going higher than 1023, I subtracted the value from 1100, but theoretically it should just be the max value.

  max value − SensorValue(lit)

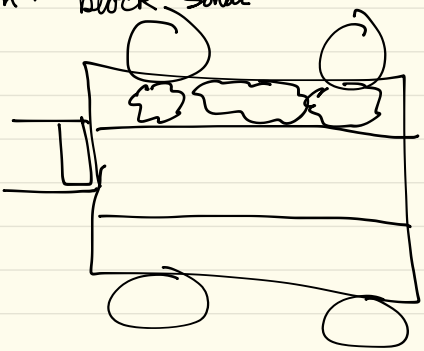
Microcontroller Programming Day 2

01/29/19

- today we have to add a sonar sensor
- For the design, we removed the bump sensors to make room for the sonar sensor
- We added two metal bars on each side of the sensor to protect it running into a wall



- next we started programming.
- I added the sensor to dgtl 7, so we imported the sensor to dgtl 7.
- we then encountered major problems!
- the robot wouldn't function when connected to the computer
- no idea what problem
  - ↳ could be debugger stopping the motor)
  - ↳ "habitual lean" - AI
- finally got it working
- Sensor checks mm distance
- So we used if statement with (sensor_value < 150)
- ends up working!
- metal prongs don't block sonar



Sensor Characteristics (Day 1)

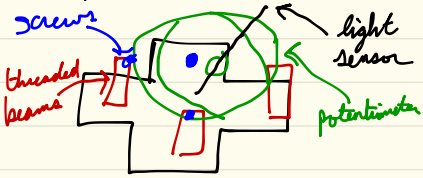
02/03/2015

1. First assignment requires a light sensor to scan for the greatest source of light & turn in that direction.
- We started off trying to get the entire robot to turn & save variables for each incremented step.
- huge margin of error
- Switched to servomotor & 2nd light sensor.
- Misunderstood that whole robot doesn't need to move. Only light sensor needs to move
- Once I understood the documentation for the Servo motor, it became quite easy
- Servo motors work under the range of [-127, 127].
  ↳ Better than other motors because it remembers & can go to specific location
- implemented a for loop w/ 2 variables: one for the light value, one for motor value
- Stopped working - unsure of hardware vs. software issue
- ended up needing += instead of + in for loop
- still not working
- needed to make it wait after moving back to highest light source
- didn't wait a full second - something to think about

Sensor Characteristics (Day 2)

02/05/2015

- Assignment 2 requires potentiometer mounting
- Very tight fit on the shaft
  - ↳ good, because you only want internal gears to move
- need to calibrate the sensor.
- changed up our design & put 3 threaded beams to allow more places for mounting



- potentiometer readings
  - ↳ (1500, 3900)
  - ↳ 2500 is middle
  - ↳ 1 degree
  - ↳ . . 180 degrees

measurements - close

45° - 1754
90 = 2600
135° = 3550

measurements - far

45° = 1750
90° = 2440
135° = 3800°

error propagation

angle	real	error
45° = 2613.9 =	1754	12.8%
90° = 2660.1 =	2600	2.26%
135° = 3306.6 =	3850	-7.36%

measurements - 1 in. - close

45° = 2613.9 =	1750	13.09%
90° = 2660.1 =	2440	8.27%
135° = 3306.6 =	3800	-14.92%

45° = 1750
90° = 2960
135° = 3260

45° = 2613.9 =	1758	13.69%
90° = 2660.1 =	2560	3.76%
135° = 3306.6 =	3260	1.41%

measurements - 1 in - far

45° = 1735
90° = 2330
135° = 3245

Sensor Characteristics (Day 3)

02/10/2015

45° = 2613.9 = 1735 13.83%
90° = 2660.1 = 2330 12.41%
135° = 3366.6 = 3245 1.86%

45° = 2613.9 = 1775 11.84%
90° = 2660.1 = 2515 5.45%
135° = 3366.6 = 3320 -.40

45° = 2613.9 = 1800 10.60%
90° = 2660.1 = 2720 -2.29%
135° = 3366.6 = 3339 -0.98%

measurements - 2in - close

45° = 1775
90° = 2515
135° = 3320

measurements - 2in - far

45° = 1800
90° = 2720
135° = 3339

- Today, catastrophe struck ...
- One group member didn't show (main hardware guy)
- We found out that we had incorrectly completed 2a. Thus, our theoretical data for 2b & 2c was off.
- We are back at 2a on the 4th day of work (including Friday)
- For 2a, we need to measure the pot readings compared to degrees at certain points given via the Servo motor.
- We took 10 readings, from -180 to 100, & plotted these points in excel
- We came up w/ a line of best fit

$y = .0696x - 95.142$

- This equation gives us an empirical formula for calculating pot results from degrees
- Hence, using our measurements from last Thursday we can show which aperture provides the least error.

degrees	servo	pot
140°	-100	3471
130°	-80	3258
118.5°	-60	3043
107°	-40	2860
95	-20	2662
85°	0	2467
82°	20	2466
74°	40	2462
64°	60	2358
50	80	2162
37	100	1955

Line of best fit = $y = -0.0696x + 95.142$

Sensor Characteristics (Day 2)

02/12/2015

- Finally onto part 3
- need to find how many sec. of turning = how many degrees
- once we calibrate, we can easily code the turn based on light

650 ms per 90°

left turn = L: 0 R: 127

right turn = L: -127 R: 0

- implemented code w/ simple if conditionals

Sensor Characteristics (Day 3)

02/13/2015

- Last day of lab
- I had a brainwave last night:

  instead of using half a dozen 'if' statements, I could use multiplication to scale the time the robot turns to the number of degrees

- At first, I tried 650/127

  650 = time for 90° turn; 127 = total motion of servo motor on one side

- However, this was horribly inaccurate since the servo readings do not relate well to degrees
- Thus, I tried 375/45

  375 = half the time for 90° turn & 45° turn; 45 = degrees

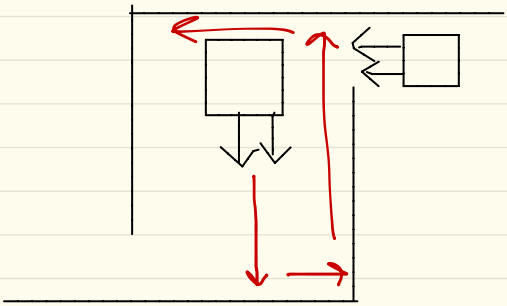
- This proved far more accurate
- In addition, I used an if statement to check if the light source is directly ahead of the light sensor. If so, the robot drives straight forward at full speed for 3 seconds.

- My first else case was if the robot sensed light to its right (from the back)
  ↳ if so, the robot moved (375/45) * the servo value to the right
- The last else case covered if the light was on the left side & functioned just like the right case, except it turned to the left.
- After coding, we ran into major issues.
- Thanks to the little tumble our robot took yesterday, our left motor clutch was no longer working. The end had been mangled.
- Hence, I removed the left side of the robot & replaced the clutch.
- After reassembly, the robot functioned properly.
- I had to adjust the first 'if' case to accept a bigger area as the "front" of the robot.

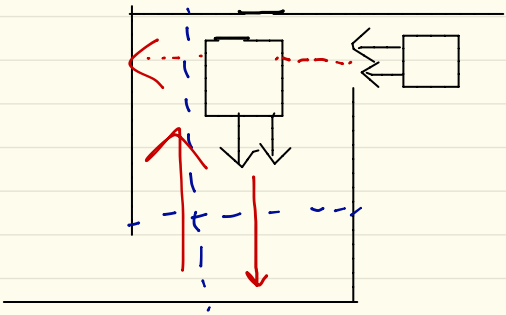
Maze Traversal

02/17/2015

- We were in lecture for most of today.
- Our task is to create a robot capable of traversing a random maze.
- There will be a light at the end of the maze.
- Perhaps I can install a bigger rod so that my current light sensor can see over the walls & find the exit...
  - ↳ I don't see how I will be able to get to my location in this manner. Perhaps this can serve as a way to choose the best option in the maze
- I was also thinking of a simple bump sensor setup. I could have the robot drive straight & automatically turn left when it bumps into a wall. & if the robot bumps into another wall soon after, then it makes 2 right turns
  - ↳ this won't work well if the maze is long
  - ↳ We have devised times for perfect left & right turns.
  - ↳ this idea would get stuck in a maze like this:



Without the double right turn, the robot will be stuck in a left turn loop



If the distances depicted by the blue lines are equal then the robot will make 2 right turns & fail

Maze Traversal

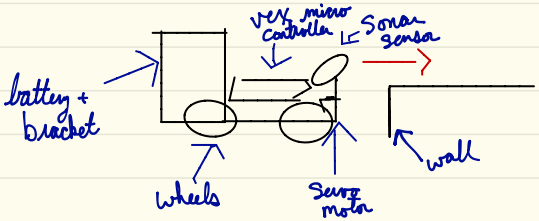
02/19/2015

- Our first day of real robot building
- we are allowed to completely reconfigure our robot.
  - ↳ I think we will keep the original squarebot design & just add the required sensors.
  - ↳ Don't fix what isn't broken.
- Our group has decided to add bumpers & use a sonar sensor attached to the servo motor from the last assignment
- We need the robot the scan how close it is to a wall and then turn if it is too close. The bump sensors are just a precaution.
- If scan all the angles in front of the robot, then we can travel in that direction for a set amount of time, or until we hit a wall. Then we can scan again.
- That's a lot of code!
- We need a scanner in a while loop.
  - ↳ We can use while(true).
- After a scan, we save the smallest servo angle to a variable & move the servo in that direction
- I have no clue how to get the robot in the same direction as the servo...
- I'll think about it tomorrow.

Maze Traversal

02/24/2015

- We're into the second week of robot building.
- I like that I have so much freedom with this project, but I wish I had a better direction.
- Our servo range - finder idea is not going to work out properly.
- I need a different idea. I looked up some robot projects online & I could only find maze-navigating algorithms for virtual robots. THAT DOESN'T HELP!
- I'm thinking we should scan the front & one side instead.
- We can then focus on going forward & not hitting a wall while still finding the best time to take a turn.
- If the sensor finds a wall in front & to the left, then it makes a right turn.
- If the robot finds only a wall to the front, it makes a left turn.
- I have started installing the sonar sensor onto the servo motor.
- I need a bracket to hold to sonar
- Nitin suggested the bracket
- The servo works with the sonar, but for some odd reason, it got switched to a different direction
- I couldn't figure out how to properly adjust the hardware so, I just set an adjustment for the left & front values in the code.
- Works well!
- I spoke too soon, it is peaking over the wall
- I will fix it on Thursday



Maze Traversal

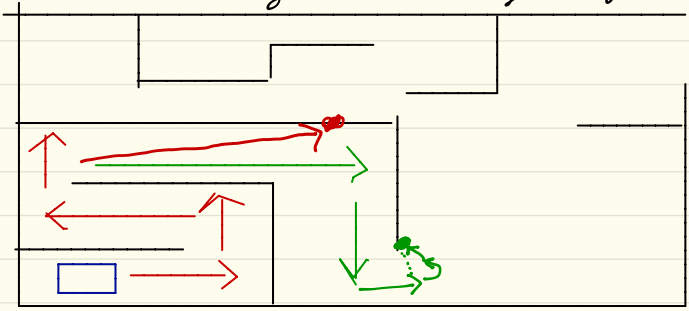
02/26/2015

- My tasks for today are to find a way to reduce the height of the sonar & finish the code for the robot
- Nitin is working on the height. I am fixing / writing the code.
- My current code has all of the import statements, followed by the main task, followed by a while(true) loop.
- Inside the while(true) loop, I have my sonar scanning the left side first
  - ↳ I move my servo to the left (exaggerated due to the weird hardware config).
  - ↳ If the value is less than 300 or so, I move on to the next loop by moving the servo to the front.
- The front loop checks if the robot is <300 from the wall.
  - ↳ if true, it turns right
  - ↳ if false, it moves outside the loop & checks if the front is <300.
    - ↳ if so, it goes left.
    - ↳ else, it goes straight
- Nitin fixed the height issue by removing some washers, but now the robot will fall apart if held upside down. Not good..
- We tested the code & immediately failed
  - ↳ we keep running into walls.
  - ↳ added a backup to the turns
  - ↳ removed from left turns
- The robot moves forward, sees a wall, backs up & turns.
- Hopefully, we'll figure out the rest next week & get the week off.

Maze Traversal

03/03/2015

- Tragedy finally struck our robot
- It won't do anything.
- We plugged it in to compile & download new code, and it stopped working.
- The result is the same whether or not it is plugged into the computer.
- We tried running start & stop on the computer & powering it on & off
- Our last resort was disconnecting the battery & charging it for a bit.
- Still not working ...
- Lo and behold, I called one of the instructors over & it started working. I hate this robot
- We are having a major tilting problem. Our robot keeps drifting left. I set all the motor commands higher for the left motor compared to the right.
- Takes forever to test.
- I have found that 64 left & 60 right makes the robot still drift left, while 65 left and 60 right makes the robot start drifting right. I can't find a midpoint.
- I tried adding weight to the right side of the robot & it worked!
- The robot actually drives straight!
- Now we're having issues with the edges hitting



My robot always finds a way to hit a wall. Sometimes it happens when it goes down long corridors, and other times it happens when making a left turn & accidentally spotting a corner. It then turns into that corner & the wall connected to it

Maze Traversal

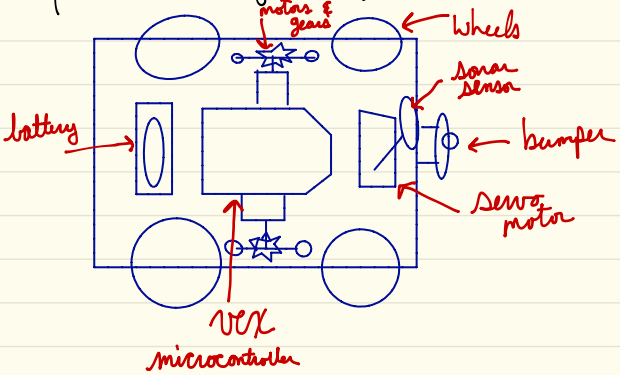
03/05/2015

- It's the last day of the 3rd week.
- I'm getting pretty nervous...
- Our robot is still struggling with corners. I don't know how to help it.
- Everyone else seems to be running their robot continuously. 2 groups are already done.
- I have no idea how they can keep running w/o scanning their distances.
- Our code is a mess as well, and I think it is causing issues.
- We have multiple while loops & if statements.
- Upon testing, we noticed the robot turns left randomly while going forward.
  - ↳ unable to diagnose the specific problem.
- We still haven't fixed the edge issue
- Sonar keeps falling off the robot
- maybe we should have worked on something simple first.
- In my 343 - Data Structures class, we talked about figuring out overarching solutions and then figuring out the smaller details
- I think I should redesign the robot & rewrite the code. But I only have 1 week.
- We're going to leave on time today & think about this over the weekend.
- I'm completely stuck

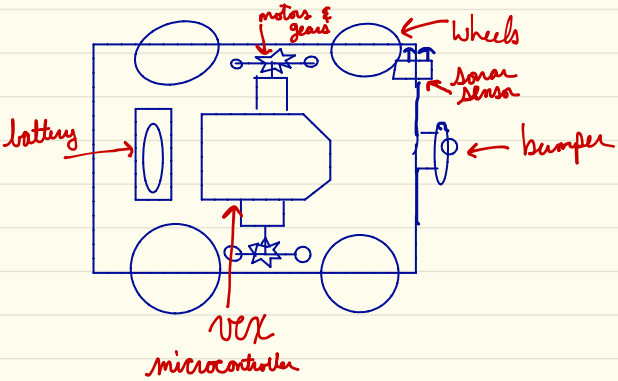
Maze Traversal

03/10/2015

- We learned the rules for the maze competition
- We have 7 minutes. Seems like more than enough time.
- My groupmates left, so it's all me.
- I have decided to take the robot apart & try to build a better robot that works w/ brand new code.
- We need a wall counter. The robot must follow the left wall all the way to the end of the maze
- It will always work!
- It will also be faster since the robot can drive until it hits a wall & then turn
- My first order of business is hardware:

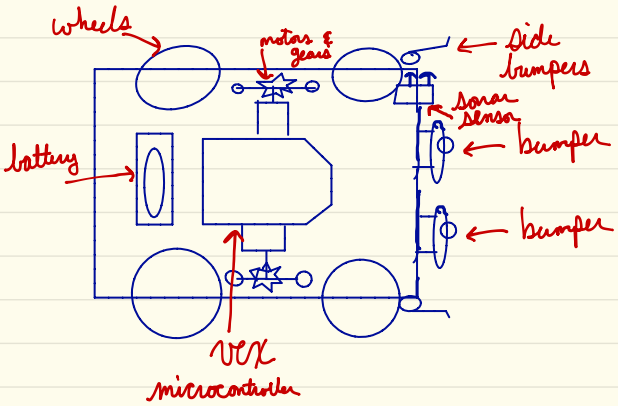


OLD



NEW

- The main change is a shift from a moving sensor to a stationary left sonar
- The code is insanely simple.
  - ↳ The inputs & left & right motor value remain
  - ↳ After the while loop, there is another while loop that deals with following the wall.
    - ↳ the conditions for the loop are that the bump sensor must not be triggered, & the sonar sensor must be <400 from the wall.
    - ↳ While the conditions are met, the robot drives forward w/ the left & right values
  - ↳ else, the robot checks if it has been bumped
    - ↳ if it has been bumped, it turns right
    - ↳ else, it turns left.
- The robot is still having issues with corners.
- I have decided to add side bumpers.
- The switches only work in one direction.
  - ↳ They don't latch on well in the opposite direction
    - ↳ I'm using lots of tape, but it doesn't hold properly.
- It keeps getting destroyed on the forward bumps.
- Attached string to keep them held. Decent Results.
- Added second front bumper to cover entire front.

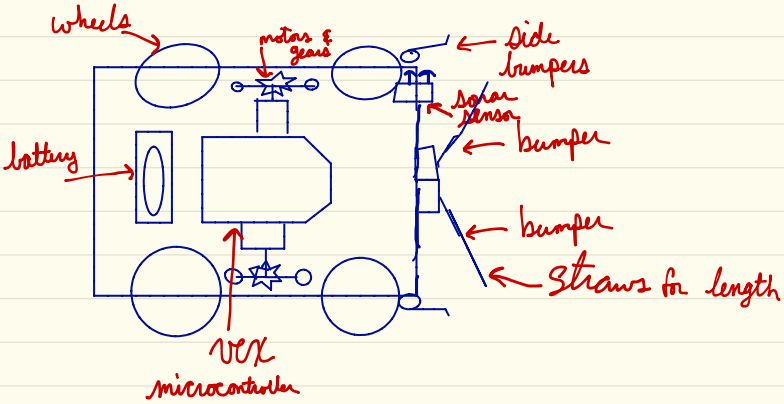


- Works almost always. Few issues w/ the edge.

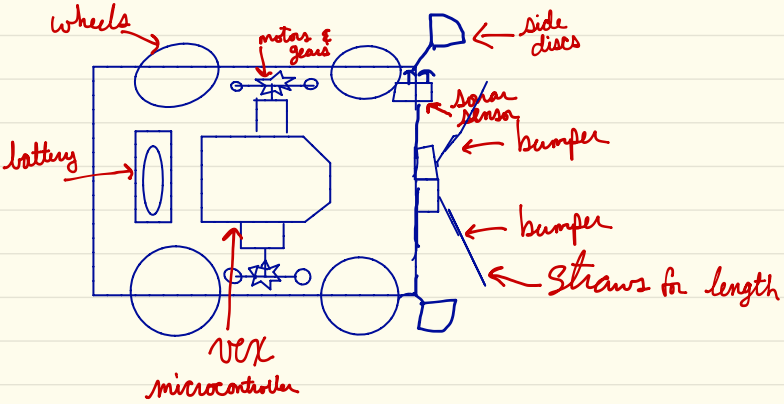
Maze Traversal

03/12/2015

- Last day for robot work!!!
- I've decided to fix my last edge issues
- I switched my 2 front bumpers for 2 front angle bumpers
  - like the ones on the side



- robot now working!
- I made it through the maze w/o adjustment
- The sensors keep getting busted
- I switched out the sensors for metal discs.



-Everything works.
-It has to be tightened a lot more so the discs don't fall back on the wheels
- Post-tightening, it's working!
- 2:05 run time w/ 21 bumps
- Ran 5 more times w/o issues.
-Time for the final run!

Maze Traversal

03/13/2015

- My robot failed today.
- There were no major adjustments to the maze
- The metal arcs kept falling back on the wheels
- It made it almost all the way through, but ran out of time
- I was very disappointed.
- I fixed it right after by adding a bracket w/ more screws